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Editors: JOSEPHINE OWEN CATTELL and JAQUES CATTELL.

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SCIENCE AND OUR NATION'S FUTURE[1]

By Dr. ARTHUR H. COMPTON
UNIVERSITY OF CHICAGO

THE nation is now calling for all its scientific strength. On the battlefields of Europe and the Orient and on the seven seas new weapons are turning the tide of battle. On both sides of the conflict determined men fight with courage and skill. If we are to win a decisive victory we must have weapons not only greater in quantity but superior in quality. Superior quality requires skilled labor and great industries with knowledge of the best techniques. It requires ingenious inventors with fertile imaginations. But basic to all is required the science that makes possible the new inventions.

When the war is won the task of maintaining a strong leadership in science will still be with us. After the hates and injustices that the war has brought, the safety of the United States in a postwar world will demand eternal vigilance. But not even vigilance is enough. If we are in earnest in striving for a peace with freedom to work for the best we know, there is only one course for us to follow. This course is to maintain with the nations friendly to us such strength that we shall not be challenged while we seek to build a world in which war will be considered as a disaster rather than as the only hope for the improvement of a people's lot.

How shall we maintain order while this peace-loving world is being built? Only by keeping ourselves strong and working for friendly relations with our neighbors.

It will require a long time thus to make the world forget war. If we are to retain our leadership it will be only through superiority in those things that make a modern nation great. Foremost among those things is science.

[1] Address during the New York Philharmonic Symphony-United States Rubber Company broadcast, January 14, 1945.

Have you ever paused to consider why the Occident has, during the past two or three centuries, come to dominate the world? You may remember that at the time of Marco Polo under the great Khan of China there flourished a civilization more powerful and more refined than Europe could boast. Somehow there arose in the West the ardent desire to know. Henry of Portugal and Columbus of Genoa, following Polo's example, went out to explore the world. Leonardo and Francis Bacon and Galileo sought to learn the hidden nature of things that they might enlarge the bounds of human empire. Newton and Lavoisier, Franklin and Faraday, Henry and Helmholtz—these great men of science opened up a vast new world. They gave to Europe and America the steam power and the firearms that meant military might. They made possible the machines of industry which supplied the means of living to greatly increased populations.

It is only very recently that the United States has taken a leading place in searching out nature's secrets. We were busy carving a nation out of the wilderness.

While Europe was refining her science, we were applying our knowledge to the every-day jobs of making agricultural machinery, electric lights and transcontinental railroads. We found these things worthwhile because they enabled more people to live better. During the last war we learned, however, that in spite of our great industrial strength, our European allies and enemies were ahead of us in devising new weapons. We found them leading us in almost all branches of fundamental science. When the war was over, our soldiers returned with a determination to learn the science that had shown itself of such value. The great educational foundations established fellowships to encourage scientific study and research. The universities rapidly built up their departments of science. By the time the second great war came we had become respected the world over for our work in science. In medicine and chemistry and physics and astronomy we trained thousands of capable young men and developed many recognized leaders. In the present war we are proud of what our men of science are doing. We have taken our full part beside our great allies in the scientific as well as the industrial aspects of this great struggle. Our enemies, both Germany and Japan, had years of head-start on us in developing machines of war. Some of these developments, such as the long range bombs, are only now beginning to be effective. Yet with our control of the submarine menace, our precise techniques of radio-location and our airplane developments, the score is perhaps turning in our favor.

The international competition for leadership in science, though on a friendly basis, is nevertheless intense. I recall in 1927 commenting to the director of Germany's great National Institute of Physics and Chemistry with regard to the high quality of his scientific instruments. Though Germany was complaining then of her poverty, in our country no universities or government laboratories could afford such equipment. The reason, said Dr. Paschen, was not far to seek. The Reichstag was determined to give all possible support to German science. They no longer had any Kaiser, nor any army. In what could they take pride? "Their men of science," they said. "Let's make of them the best in the world."

This was the spirit that has enabled our enemy to match step by step the combined technical developments of ourselves and our allies. It is true that when the Nazis came into power, the study of fundamental science was greatly curtailed and even the technical schools fell to roughly 25 per cent. of their full enrolment as they were building up their armies just before 1939. Yet this did not go as far toward destroying their scientific strength as we have gone in weakening our own science in this war. Just as the war began, the Germans came to realize the danger to their future because of their failure to train enough scientific and technical men. They set aside an increased group of young men best qualified for science and barred them from entering the armed forces.

At least until perhaps very recently these students have been continuing their training for careers in science and technology. The result is that the German war industries and research organizations have an indefinitely continuing supply of fully trained men.

Our national policy with regard to the training of scientific men has been precisely the reverse. We have gambled on a short war. Science professors and students alike have left the universities. All their effort is concentrated on devising and developing new and improved weapons. Because we were caught unprepared for a war in which scientific developments have become so vital, this has seemed to be the only possible procedure. Yet now practically no students over 18, except a few 4-F's, are studying science.

If the war could have been completed within a year or two this policy would have been a good one. The idea is that every one puts all that he has into the fight now, and gets it over with, and then all return as promptly as conditions permit, to resume their normal tasks. But the war in Europe has already been going for over six years, and our three years of intense effort have not shown us clear evidence of an early victory. If the war should continue for as long as it has already been fought, our present policy of no advanced scientific and technical training will spell national disaster.

It takes at least six years for a capable eighteen-year-old to train himself for effective scientific research. Even if we should start now to resume such

training, it will thus be at least six years before a normal supply of young professionals will again be available to our laboratories. Can we afford to wait any longer?

This is a situation of national concern which needs to be carefully watched lest when the war is won we may find that we have gained a Pyrrhic victory, having lost so much of our technical strength that we shall be unable to carry on the great task of world leadership which we now see before us.

It remains for those who follow me on this program during the next weeks to explain how the growth of science will bring to us life of greater human value. Increased cooperation and concern for each other's welfare, greater attention to education for everybody, fresh consideration of the goals of living worthy of our great new powers, such human developments are sure consequences of the emphasis that science places on specialized skills and on coordinated effort in learning and using knowledge. But more of this later.

What I want to bring to you to-day is the fact that greatly increased emphasis on science is a "must" for our nation's safety and future welfare. If a wise course is followed with regard to training and in other support of science, our nation is in favorable position to lead the world in the scientific age that lies ahead.

THE CONCEPT OF INTEGRATIVE LEVELS AND BIOLOGY[1]

By Dr. ALEX B. NOVIKOFF

DEPARTMENT OF BIOLOGY, BROOKLYN COLLEGE

THE concept of integrative levels of organization is a general description of the evolution of matter through successive and higher orders of complexity and integration. It views the development of matter, from the cosmological changes resulting in the formation of the earth to the social changes in society, as continuous because it is never-ending, and as discontinuous because it passes through a series of different levels of organization—physical, chemical, biological and sociological.

In the continual evolution of matter, new levels of complexity are superimposed on the individual units by the organization and integration of these units into a single system. What were wholes on one level become parts on a higher one. Each level of organization possesses unique properties of structure and behavior which, though dependent on the properties of the constituent elements, appear only when these elements are combined in the new system. Knowledge of the laws of the lower level is necessary for a full understanding of the higher level; yet the unique properties of phenomena at the higher level can not be predicted, *a priori*, from the laws of the lower level. The laws describing the *unique* properties of each level are qualitatively distinct, and their discovery requires methods of research and analysis appropriate to the particular level. These laws express the new organizing relationships, *i.e.*, the reciprocal relationships of elementary units to each other and to the unit system as a whole.

The concept of integrative levels recognizes as equally essential for the purpose of scientific analysis both the isolation of parts of a whole and their integration into the structure of the whole. It neither reduces phenomena of a higher level to those of a lower one, as in mechanism, nor describes the higher level in vague non-material terms which are but substitutes for understanding, as in vitalism. Unlike other "holistic" theories, it never leaves the firm ground of material reality. Integration does not imply, as Lillie has recently maintained, "special vital factors"[2] or "something of the mental or psychic."[3] Both parts and wholes are material entities, and integration results from the interaction of the parts, as a consequence of their properties. The concept points the need to study the organizational interrelationships of parts and whole. This full recognition of both units and whole leads to a more adequate understanding of the whole.

The different levels of matter, while distinct, are not completely delimited from each other. No boundary in nature is fixed and no category air-tight. "Mesoforms" are found at the transition point of one level of organization to the next. Between the highest level of organization of non-living, the crystal, and the lowest level of unicellular organisms are protein paracrystals, the viruses, with some of the internal structure and behavior of living substance. Between the single-cell organism and the multicellular organism are the colonial organisms. Yet the absence of rigid demarcation between two levels does not make the difference between them any less clear or fundamental. Mesoforms, "the more clearly we understand them, will all the more clearly serve to bring out the essentially new elements of (the) higher order."[4]

There is both continuity and discontinuity in the evolution of the universe; and consideration of one

[1] Contribution No. 62.

[2] Ralph S. Lillie, *The American Naturalist*, 72: 414, 1938.

[3] Ralph S. Lillie, *Philosophy of Science*, 7: 327, 1940.

[4] Joseph Needham, *The Modern Quarterly* (London) 1: 30: 1938.

to the exclusion of the other acts to retard the development of biological and sociological sciences. Knowledge of the general qualities of development common to all levels of organization of matter will aid in the analysis and description of the concrete attributes of each level. But it can not be a substitute for such analysis or for the determination of the qualitative uniqueness of each level and the characteristic laws which govern it.

PHYSICO-CHEMICAL AND BIOLOGICAL LEVELS

The concept of integrative levels does not regard living organisms as machines made of a multitude of discrete parts (physico-chemical units), removable like pistons of an engine and capable of description without regard to the system from which they are removed. Its approach is one which biochemists are adopting more and more: living cells present problems not to be encountered in the test-tube or flask. The structural pattern of the cell plays a decisive role in many of the chemical reactions which constitute metabolism. The ordering, as well as speed, of the chemical reactions in the cell are largely the result of the distribution and activity of colloidal enzymes. Korr[5] has indicated that even simple colloidal systems "represent a much higher level of integration . . . and that, because of the quantitative and qualitative modification which interfaces and their molecular groupings impose, there emerge new classes of phenomena for which there are no analogies in homogeneous systems, and which, therefore, require new sets of rules." Commoner[6] has discussed the increased dependence of enzyme function on structural factors in the living cell. The degree of dependence of a particular enzyme system on protoplasmic structure or physico-chemical organization can be revealed by changes in this structure, both natural and experimentally produced.

It has been the great contribution of the "organicists" that they have demonstrated the error of the mechanistic reduction of the biological organism to the physico-chemical. It is therefore unfortunate that "organicism" has been marred by non-material concepts. Organicists fail to picture the "whole" as developing through the integration of individual units of matter into a single system; they omit a discussion of the organizing relationships of the parts. They try to describe the behavior of the organism solely in terms of the higher level, the whole. As a result, the impression is created that no material basis exists for the part-whole relation.

Almost all the text-book definitions of physiology reduce phenomena of living matter, a highly complex and integrated system, to the level of free molecules and atoms. Certainly chemical and physical forces are operative in cells, yet defining physiology as "the physics and chemistry of life processes" overlooks the fact that the cell organization imposes a new and higher order on physico-chemical change, and that tissues, organs, organ-systems and organism impose a higher order on cell activity. Physiology rightly concerns itself also with the activities of the higher orders: cellular organization and function as well as chemistry and physics in the narrow sense; the tissue, organ, organ-system as well as the cell. No matter how complete our knowledge of the chemistry and physics of living systems becomes in the future, living substance must still be recognized as matter on a higher level, with new, unique properties which have emerged on combination of the lower-level units. When molecules become part of a highly integrated system, protoplasm, it is important to know the properties of the molecules, but protoplasmic behavior needs description in terms and laws which have no meaning for molecules, in specifically biological terms and laws.

BIOLOGICAL LEVELS

Within the biological level, there are a series of other integrative levels.

I

In the multicellullar organism there is a hierarchy of levels—cells, tissues, organs, organ-systems and organism. Viewed in terms of integrative levels, Heilbrunn's assertion that "general physiology thus becomes cellular physiology" and that "the ultimate mechanism responsible for any form of vital activity lies inherent in the individual cells"[7] is one-sided. A full understanding of the organism is not possible without complete knowledge of the activities of its cells. But knowledge of "the individual cells" does not exhaust the problems of organism physiology; the activity of the individual cell is greatly influenced by the products of activity of other cells in tissue, organ, organ-system and organism.

The inadequacy of a cell concept in which the cell is considered an independent unit of activity is clear from the work of experimental embryologists. The embryo is not a collection of unrelated portions developing independently of each other; on the contrary, the development of any cell is dependent not only on its own constitution but also on the nature of the surrounding materials outside the egg or produced in adjacent cells of the embryo. If ectoderm cells which normally form belly skin were removed from a salamander embryo and transplanted over the mouth organizer of a frog embryo, they would develop into

[5] Irvin Korr, *Cold Spring Harbor Symposia*, 7: 74, 1939.

[6] Barry Commoner, *Quarterly Review of Biology*, 17: 46, 1942.

[7] L. V. Heilbrunn, "An Outline of General Physiology," pp. 3, 4. Philadelphia, 1943.

salamander structures—of the mouth; they would form teeth and not belly skin.

Similarly, in the adult organism, plant or animal, the behavior of a cell is influenced by the activity of other cells of the body. Thus, the hormone, auxin, produced in the apical cells of a plant, will cause the elongation of stem cells, inhibit the growth of cells of lateral buds, influence the course of differentiation of root cells and stimulate the growth of cambium cells. Chiefly through such hormones, the cells of the plant body are integrated into an organism. In animals, the activity of cells is under the integrating influence of nerve impulses, hormones and other cell products like carbon dioxide. Activity of cells of the salivary glands is dependent upon stimulation by nerve impulses begun elsewhere in the body. The behavior of uterine cells depends not only on its own constitution, but also on hormones produced by cells of pituitary and ovary. Carbon dioxide produced by muscle cells in the legs will influence the behavior of the respiratory center cells in the medulla.

Just as cells do not exist in isolation in the organism, neither do organs or organ-systems. Thus, the functioning of the heart (the rate and force of its beat) is not unrelated to the pressure of the blood in the aorta and carotid arteries, the diameter of the arterioles or the amount of blood returning through the veins; nor is the circulatory system unaffected by or without effects on the nervous, endocrine, muscular or respiratory systems. Coghill,[8] using embryos, and Lashley[9] and Goldstein,[10] studying adult animals and men, have demonstrated the weakness of an atomistic approach to the activity of the nervous system and have emphasized that it functions as an integrated whole.

II

Populations constitute a distinct level of integration, higher than that of the individual organism. Schneirla, in his excellent studies on the interrelations between individual behavior of the army-ant and the population unit or colony, stresses this point. "Any social organization represents a qualitatively new emergent level not equivalent to that which might be attained through a mere summation of the properties of its constituent individuals."[11a] It is solely the reactions of the individual ant which are responsible for the highly organized mass behavior; yet "strictly speaking, the Eciton worker has no behavior pattern outside the social sphere."[11b]

Dobzhansky, in his authoritative work on population genetics, similarly describes populations as higher levels of integration. The fate of a newly-arisen genetic variant depends not alone on its effect on the individual organism but also upon the "dynamic regularities of the physiology of populations." Thus, it is the effective size of a population which may determine whether a useless or even deleterious mutant will, through chance recombinations, become incorporated into the constitution of the group. The smaller this population size the less effective is selective pressure in evolution. Dobzhansky emphasizes that evolutionary changes are changes in the genetic constitution of groups—of populations. Through natural selection, migration, and isolation, biological groups are produced whose genetic structure is molded in relation to the environment. The laws of population genetics which describe these evolutionary changes are on a higher level than those of the genetics of the individual. "The rules governing the genetic structure of a population are, nevertheless, distinct from those governing the genetics of individuals, just as rules of sociology are distinct from physiological ones, although they are in fact merely integrated forms of the latter."[11c]

The concept of integrative levels stresses the need to study living organisms at all levels—cells, tissues, organs, organ-systems, organisms and populations. It is not "organicist"; always the reciprocal relationship of elementary units to each other and to the unit system as a whole must be studied. It is not mechanistic; the detailed methods of study at higher levels will include not only some used at lower levels but new methods peculiar to the higher levels; the laws of one level will be expressed differently from those of the others.

Biological and Social Levels

According to the concept of integrative levels, man's social relationships represent a new level, higher than that of his biological make-up. Man's behavior differs from that of other animals because of his possession of body structures, notably, the highly developed nervous system, which make thought and speech possible and whose functioning is profoundly affected by social or cultural influences. Man possesses a unique head and hand, and is able to confront nature not only with his body but with tools devised and wielded by him. The crude tools of primitives give way to the more complex technology characteristic of modern society. As the technological forces change, the social and economic relations of men change, and, with them, man's behavior. Socio-economic or cul-

[8] G. E. Coghill, SCIENCE, 78: 131, 1933.

[9] K. S. Lashley, "Brain Mechanisms and Intelligence," Chicago, 1929.

[10] Kurt Goldstein, "The Organism." New York, 1939.

[11] (a) T. C. Schneirla, *Psychological Review*, 48: 465, 1941; (b) *idem, The Journal of Comparative Psychology*, 29: 447, 1940; (c) Theodosius Dobzhansky, "Genetics and the Origin of Species," p. 11. New York, 1941; (d) Francis H. Bartlett, "Sigmund Freud," p. 80. London, 1938.

tural forces thus come to dominate biological factors in directing man's actions.

In a penetrating analysis of Sigmund Freud's failure to recognize the inseparability of the biological and the cultural forces which determine man's behavior, Bartlett writes,

> The biological organism, by its existence in society, has become a "new biological species." . . . The biological organism is transformed; it no longer exists as a biological phenomenon, strictly speaking. Under the influence of society, the biological has become the psychological. New laws of motion have come into being which are neither biological nor sociological, but the subject of study of a different science, psychology.[11d]

The concept of integrative levels, as it stresses the need to study the interrelationships between the biological and sociological, emphasizes the fact that the two constitute two distinct levels. Blurring this distinction leads to anthropomorphism and to mystical, often dangerous, statements about society.

Anthropomorphism—endowing animals, and even plants, with human attributes, psychical and social—transports the higher level (social) bodily into the lower level (biological). In doing so, it presents a wholly erroneous picture of the animal. The aspects of behavior common to man and animals are studied in comparative psychology, just as comparative cytology studies the uniformity of structure of diverse cells and comparative biochemistry the fundamental chemical changes common to all cells and organisms. Often, the significance of certain aspects of man's behavior (*e.g.*, instincts) can be illuminated by studies on lower animals where the problem may be analyzed more directly. And in the anthropoid apes, it is possible to investigate the beginning of reflective thought and of social influences on behavior.

Yet the study of animal behavior can not be a substitute for the study of man's behavior. As we establish the likenesses in behavior of animals and men, we must simultaneously investigate the fundamental qualitative differences between them. Except in certain pathological conditions, man's behavior is as unique as the organs which he, alone of all animals, possesses; thought, speech, labor are impossible without a highly developed brain and a hand. It is his unique biological constitution which makes possible the development of truly social relations among men. Many investigators studying the integrated animal populations, the so-called societies of animals, appear to have overlooked the fact that animal societies never rise above the biological level, that only man's society is truly sociological.

Any one who has tried to teach biological change to college students knows the barriers to learning which have been created by the identification of animals with men throughout the student's lifetime. Every phenomenon is approached by them in terms of human experience. There is no time scale other than the clock, calendar or century. Yet important biological change can be expressed only in a "non-human" time scale. For each living organism travels at two enormously different speeds of life.[12] The comparatively rapid one is easy to comprehend because the changes can be observed; the birth, growth and death of the body, the movement of the plant on the window sill, and even the less obvious chemical changes of cells and organisms. But only the end results of changes over many thousands of centuries can be seen in the diverse plants and animals, each almost perfectly adapted to its environment. A species, in high-speed terms, is constant; but in low-speed terms, it is changing.

Thinking in high-speed terms of these low-speed phenomena leads almost inevitably to teleological conceptions, ascribing these phenomena to a divine purpose in nature. The terrestrial mammal has no gills because the air, containing little water, would dry out the exposed soft tissues; the earthworm has no eyes because it has no need for them, buried as it is in the ground. Such teleological reasoning is carried over even to changes which are directly observable. The heart beats in order to bring food-laden blood to all cells of the organism. The leaf bends to the light in order to intercept more energy for photosynthesis. There is no awareness that ascribing such purposive behavior to the heart or the plant imparts the ability to reason and to look into the future, in one case to a small individual part of the organism, and, in the other, to an organism which lacks a nervous system, let alone a brain!

The history of biology demonstrates that teleology explains nothing, and, worse still, hampers the search for explanations and causes. You do not study the causal development of eyes in worms if you believe their absence in earthworms is explained by the statement that underground worms need none. Nor do you trouble to analyze the causes of cardiac muscle contraction or the distribution of plant growth hormones if it suffices to say that the heart beats to pump blood and the leaf bends to get light. You do not study the causes of evolution or the explanation of mutual adaptation of organism and environment if you assert, as Gerard has recently, that the "selection or creation of these particular mechanisms" is volitional or purposive.[13] Only when purpose was excluded from descriptions of all biological activity except rational behavior of human beings, could bio-

[12] Henry Collier, "An Interpretation of Biology," Chapter 5. London, 1938.

[13] Ralph W. Gerard, "Organic Freedom," p. 425, in "Freedom, Its Meaning," edited by R. N. Anshen. New York, 1940, *Scientific Monthly*, 50: 349, 1940.

logical problems be properly formulated and analyzed.

CRITIQUE OF SOME BIOLOGICAL LITERATURE ON INTEGRATIVE LEVELS

In a recent volume devoted to the concept of integrative levels,[14] a number of serious errors occur. These errors stem from a tendency to concentrate exclusion of any consideration of the uniqueness of ter from low to high levels. While the "organicists" concentrate their attention exclusively on the uniqueness of the biological level ("the organism as a whole") without relating it to the lower levels, this tendency is preoccupied with the general similarity of organizational development in evolution to the exclusion of any consideration of the uniqueness of each level. This overemphasis of the continuity of evolution leads to the confusion of biological and sociological levels.

A. E. Emerson acknowledges the distinction between biological and social sciences but then says, "Society is surely a manifestation of fundamental life attributes which are shared with other biological systems and the division between the social and non-social is not sharp."[15] Elsewhere, he maintains that "the evolution of human social and ethical characteristics is governed by the same forces which have been directing organismic evolution through the ages."[16] However, the material in Emerson's articles reveals the basic difference between the forces making for change in human society and those producing changes in "organismic evolution." There has apparently been no important change in the society of insects in the thirty-five million years since the Oligocene period. Since insects possess neither intelligence nor the ability to transmit the results of experience to others, change is dependent on the slow process of germinal change (mutation) and their society is therefore relatively fixed. On the other hand, in the seven or eight thousand years of recorded history, man's society has continually changed; because of the transmission of experience symbolized by tools, language, printing, photography, etc., there is social-cultural inheritance as well as biological inheritance. It is the plasticity of man's intelligence which brings ethics into being.

While man's social relations have undergone marked transformation, his biology has remained essentially unchanged. What small biological change has occurred (*e.g.*, increased mean length of life) has been the result and not the cause of social development. The "forces . . . governing . . . human social and ethical characteristics" have been not biological but social, the relation of man to changing technological and economic relations. The "forces . . . governing . . . organismic evolution through the ages" have been biological (mutation, etc.). That is why whatever similarities one notes in animal and human societies must be purely formal and therefore meaningless.

Gerard accepts the old analogy between society and the living organism and, by what Simpson has aptly described as the "most reckless, unjustified, and nonscientific extrapolation,"[17] he draws a great many parallels between aspects of society and organisms. Thus, he equates scientists with receptors,[18] the formation of an army by a nation with the fusion of slime molds in the face of "emergency conditions,"[19] altruism of men with "service and mutual helpfulness seen in the interplay of cell nucleus and chloroplast,"[20] and so on. It is unnecessary to enumerate all the parallels. In every one of them, the social activities for which Gerard finds biological counterparts are not of biological origin but are the results of long processes of social development. We can not overlook the fact that the origin of social integrations of rational men in society is fundamentally distinct from that of biological integration of masses of protoplasm in the living organism. Aside from its refinement in terms of modern biological data, the organism-society analogy of Gerard is the same as that of Herbert Spencer in which, Needham has pointed out, instead of seeking the economic basis of social relations, he "elaborates to a degree sometimes almost fantastic the analogy between animal and social organisms."[21]

Just as the striking but fundamentally misleading analogy between living organisms and non-living engines has stimulated both mechanical and vitalistic biology, so this organism-society analogy leads to erroneous and dangerous social conclusions as well as to anthropomorphism.[22] Because he fails to distinguish the social from the biological, Gerard[23] is led

[14] Biological Symposia, VIII. "Levels of Integration in Biological and Social Sciences," edited by R. Redfield. Lancaster, 1942.

[15] Alfred E. Emerson, "Basic Comparisons of Human and Insect Societies," p. 173, in Redfield, *op. cit.*

[16] Alfred E. Emerson. Abstract 21423, in *Biological Abstracts*, vol. 16, 1942.

[17] George G. Simpson, *Journal of the Washington Academy of Sciences*, 31: 18, 1941.

[18] R. W. Gerard, "Higher Levels of Integration," p. 79, in Redfield, *op. cit.*

[19] *Idem*, "Higher Levels of Integration," p. 81.

[20] *Idem*, "A Biological Basis for Ethics," p. 108. *Philosophy of Science*, vol. 9, 1942.

[21] Joseph Needham, *The Modern Quarterly* (London), 1: 38, 1938.

[22] Needham, Huxley and Simpson have noted that even the formal aspect of the organism-society analogy is erroneous because it overlooks the fundamental differences between organism and society in: (1) the degree of concentration of consciousness in specialized parts, (2) the degree of differentiation arising during reproduction (of individuals in society and of cells in organisms), (3) the mode of reproduction and inheritance, and (4) the degree of subordination of individual parts to the whole.

[23] R. W. Gerard, "Higher Levels of Integration," pp. 83–85.

to formulate a single principle to govern the entire historical process from the origin of molecules to the development of human society, the progressive growth of cooperation and altruism. By oversimplifying phenomena and divesting each level of organization, among organisms and in society, of its specific characteristic qualities, a metaphysical statement is produced, to the effect that society will inevitably—because it is an organism—progress toward a cooperative state. "The ultimate future of society, however dark it may look to the contemporary sociologist or even to the historian, appears in the eyes of the biologist, sighting down the long perspective of organic evolution, as bright with hope."

It should be remembered that even in the biological world, evolution is not always in the direction of progress—witness the "regression" of the tapeworm. We can not afford to take refuge in Gerard's idea of a mysteriously operating "organizing trend"[24] which will insure the steady march of progress for man's society. Such evolutionary fatalism is unsound science, and dangerous social advice for it leads only to inaction. Fortunately, the United Nations are not guided by such fatalism; they are relying not on any "trend," but on their armed might, in order to defeat fascism and keep society on the road of progress.

Despite occasional backward movements and many blind alleys, biological evolution has moved in the direction of progress—towards more and more highly integrated and efficient organisms in which there is an increasing independence of and control over the external environment. This is to be explained on the basis of phenomena such as genetic mutations and natural selection. We may agree that, despite more or less temporary setbacks, society will develop eventually to a high level of cooperation. But it will do so not because of "organizing trends," mutations or natural selection. Discussion of social evolution in terms of natural selection as it applies in the biological world is no more meaningful than metaphysics, for, as we have indicated, without a study of man's socio-economic relations, it is impossible either to explain the past history or to indicate the prospects for the future development of society. Progress in social development is basically different from progress in organic evolution; the latter does not involve conscious activity, the former, depending on scientific and technological advance, is the result of conscious activity of men and is directed by experience of life and study of history. Progress in organic evolution occurs without a set plan or direction; social progress rests upon planned activity of men. As Huxley says, human progress "is not inevitable; man . . . must work and plan if he is to achieve further progress for himself and so for life."[25]

Needham[26] has demonstrated that the most dangerous aspect of the reduction of social phenomena to the biological level, at the present historical moment, is the basis it provides for fascist "philosophy." The central point in this "philosophy" is the thesis that man's biology decides his social behavior, and ruthless oppression of certain groups of people is justified because these groups are for all times fixed as "inferior" by their biology. Gerard's view gives indirect support to this thesis, by making biological principles the guide for social thought and action.

A sharp separation of the two levels—biological and social—must precede a fruitful discussion of how man's society can be kept free and democratic. That discussion must be based on a study, by means appropriate to the level, of the social forces making for change. Only a scientific analysis of these forces will enable man to speed social progress.

It is perhaps not surprising that Gerard's one-sided view of evolution—which ignores the qualitative differences of successive levels of integration and the specific part-whole relationships in each—should lead him to embrace the concept of purpose.[27] The retarding influence of teleological thinking on the advance of biological science has already been referred to. Here we add our agreement with Huxley that any "apparent purpose" in evolution is "just as much a product of blind forces as is the falling of a stone to earth or the ebb and flow of the tides. It is we who have read purpose into evolution, as earlier men projected will and emotion into inorganic phenomena like storm or earthquake. If we wish to work towards a purpose for the future of man, we must formulate that purpose ourselves. Purposes in life are made, not found."[28]

Conclusion

The concept of integrative levels describes the progress of evolution of the inanimate, animate and social worlds. It maintains that such progress is the result of forces which differ in each level and which can properly be described only by laws which are unique for each level. Since higher level phenomena always include phenomena at lower levels, one can not fully understand the higher levels without an understanding of the lower level phenomena as well. But a knowledge of the lower levels does not enable us to predict, *a priori*, what will occur at a higher level. Although some may have validity for the higher level, laws of a

[24] *Idem*, "A Biological Basis for Ethics," p. 108.

[25] Julian Huxley, "Evolution, The Modern Synthesis," p. 578. New York, 1942.

[26] Joseph Needham, Foreword to Prenant, "Biology and Marxism." New York, 1938.

[27] See references, note 13.

[28] Julian Huxley, *op. cit.*, p. 576.

lower level are inadequate to describe the higher level. The laws unique to the higher level can be discovered by approaches appropriate to the particular level; to do otherwise is invalid scientifically and, in some instances, dangerous socially.

By stressing the material interrelationships of parts and whole and the qualitative uniqueness of each level of integration, the concept is of genuine help to biologists. Its dialectical approach avoids "organicism," "fatalism" and mechanical "atomism," and helps attain a fuller understanding of such problems as the interrelations of cellular structure and metabolism, of cell and organism in ontogeny and in adult physiology, of individual and population biologies, of biological and social factors in the development of man's behavior; and the mechanisms responsible for organic evolution. By avoiding teleology, the concept aids the search for causes of biological phenomena.

The concept of integrative levels indicates to research biologists the crucial aspects of their problems, the solution of which puts the known facts into proper perspective by revealing the decisive element, the element imparting the uniqueness to the phenomena under study. It emphasizes the importance of studying the "mesoforms," matter at the point of transition from one level of organization to the next, so as to deepen our understanding of the unique qualities of the higher level. For example, it would indicate that an intensive study of the transition region between the chemical and biological levels, between protein and protoplasm, will help reveal the organizing relations unique to living matter and fundamental to vital activities.

As biologists become more familiar with the concept, a greater number will recognize its value both as an aid in the understanding of biological data already accumulated and as a reliable guide for research. Such recognition of its value will, however, be delayed by any presentation which creates the erroneous impression that it is metaphysical, teleological or mystical. This article has pointed to shortcomings in the presentation of the concept in some recent biological literature, with the hope that this may help make future references to the concept more reliable.

OBITUARY

SIR ARTHUR EDDINGTON

THE death of Sir Arthur Eddington deprives astrophysics of its most distinguished representative and the philosophy of science of its most notable expositor.

Appointments to major scientific posts in England have been made with a very high average of success. The electors have shown excellent judgment in picking the ablest men and courage in putting them, while young, into positions which gave them adequate opportunities. They never did better than when a young man of twenty-four was appointed chief assistant at the Greenwich Observatory in 1906. His early work—a series of papers dealing with the motions of the stars and the dynamics of star-clusters—was notable for the thorough insight into the problems and skill and elegance in their mathematical discussion which marked his later work. It may not be as well remembered that he was also a very competent observer. A floating photographic zenith telescope (supported by a mercury bath) had failed to give results of the anticipated precision. Eddington took on this discouraging problem, and found that the errors could be eliminated by changes in the details of observing methods. The instrument was thus started on a program of almost thirty years of successful operation, interrupted only by the present war.

In 1913 Eddington was elected, at the age of thirty-one, to the historic Plumian professorship at Cambridge. Again the judgment of the electors was fully vindicated.

His interest in physical problems now became predominant, and he entered upon the most notable period of his career, with his studies of the internal constitution and radiation of the stars.

These form a contribution of the highest order to the progress of physical science. When he began, a large number of properties of the stars were known, from the observations of the preceding decades, and the properties of atoms were also fairly well understood. By analysis of remarkable incisiveness and skill, he established the relations between the two, and ended by showing that the stars had to be what they were, just because they were composed of atoms. He proved that only large masses—exceeding fifty thousand times that of the earth—could shine brightly enough to be seen at distances of even a few light-years, and that all larger masses must inevitably so shine, with a brightness depending mainly, though not entirely, upon the mass, and increasing very rapidly with it. These conclusions were fully confirmed by the observed data, and the era of secure interpretation, rather than empirical study, of the properties of the stars began.

The greater part of this work is presented in "The Internal Constitution of the Stars" (1926). This volume marks an epoch in the progress of astrophysics. It is no less admirable as an example of the

too-rare art of scientific presentation. The temptation is seductive to the busy scientific worker to make a book by compilation from earlier publications or lecture notes. Here Austin Dobson's exhortation to the artist

> See that thy form demand
> The labour of the file.

has been followed, and the book is a unit—the work of a great teacher as well as a great investigator.

After nearly twenty years, this book is still required reading for the advanced student. In some matters—such as the source of stellar energy—the advance of knowledge has superseded Eddington's tentative suggestions, but the main lines of his investigation still stand evidence of his remarkable insight. This is equally true of his studies on variable stars (pulsating and eclipsing) and on diffuse matter and gas in interstellar space.

The third period of Eddington's work was devoted to the presentation of arguments leading to the conclusion that the primary properties of matter—especially those which are represented by the dimensionless constants which occur in nature—may be deduced by abstract epistemological reasoning from very general considerations. Upon these investigations the writer is not qualified to speak.

No summary of his work would be complete without mention of his epigrammatic wit—and as his description of the imaginary Scottish professor of Geloecology who thoroughly understood the rules of this hypothetical science of humor, and could infallibly classify any kind of joke—without ever having *seen* one!

Few people cared less for formal distinctions. One of the writer's most vivid memories of him is of delegates gathering at their hotel before a formal banquet, at which courtesy demanded the wearing of decorations—and of Eddington with an ancient rain-coat buttoned tightly at the neck—to hide the Order of Merit!

He never married; his widowed mother and his sister (who survives him) made for him a home perfectly adapted for his temperament and his work. After a short illness, he died on November 21, 1944, leaving a name which will endure in the annals of science.

HENRY NORRIS RUSSELL

RECENT DEATHS

DR. FRED H. ALBEE, orthopedic surgeon of New York City, died on February 16 in his sixty-ninth year.

DR. MARK J. SCHOENBERG, ophthalmologist, died on February 15. He was seventy years old.

SCIENTIFIC EVENTS

ARCHEOLOGICAL WORK OF THE NATIONAL GEOGRAPHIC SOCIETY

THE war has forced the National Geographic Society to curtail its scientific field expeditions, but the archeological studies that have been made annually since 1937–38 in southern Mexico under the sponsorship of the society and the Smithsonian Institution will be continued.

The seventh expedition, led by Dr. Matthew W. Stirling, is on its way to the southernmost Mexican State of Chiapas, where, digging into burial mounds and clearing jungle growth, he will continue the study of pre-Columbian civilization in this hemisphere. Dr. Stirling is accompanied by Mrs. Stirling and Richard H. Stewart, geographic staff photographer.

The expedition this year plans to conduct its studies in the mountains east of the Isthmus of Tehuantepec. According to Dr. Stirling, pottery and jade objects, which have given important clues to the pre-Columbian peoples who inhabited other regions of southern Mexico where he has visited, have been reported southwest of Tuztla Gutierrez.

The former expeditions have followed the early Olmec culture down the east coast of southern Veracruz State and into Tabasco. Explorations last year demonstrated that the Olmecs did not extend their civilization beyond the middle of the State of Tabasco, but turned towards the Pacific Ocean, following the mountains bordering the Isthmus of Tehuantepec.

Six carved basalt heads of fifteen to twenty tons each were unearthed. Their origin and use after they were carved about seven centuries ago still is a challenge to archeologists. Near Tres Zapotes the expedition discovered a stone bearing, in Mayan symbols, the earliest recorded date found in this hemisphere—November 3, 291 B.C.

Members of the expedition picked up figurines of jade and clay, one of the latter with wheels. It is believed that this doglike figurine was made about a thousand years ago and thus is probably the earliest evidence of the use of wheels in the western hemisphere.

Another find was a priceless cache of jade. The expedition had been in the field nearly four months in 1941 and was about to break camp when it unearthed seven hundred and eighty-two pieces of jade fashioned into rings, human and animal figures, ear plugs and pendants.

BIOLOGICAL ABSTRACTS

DR. STUART MUDD, professor of bacteriology at the University of Pennsylvania, and Dr. Charles N. Frey,

director of the Fleischmann Laboratories, Standard Brands, Inc., New York, were elected to membership on the Board of Trustees of *Biological Abstracts, Inc.*, at the annual meeting held in Philadelphia on February 3.

Approximately 3,000 collaborators assist in the preparation of abstracts; 1,100 of them have assignments for abstracting one or more journals in entirety. Arrangements are made for abstracting about 1,925 journals. The abstracts are edited by 157 section editors and assistants. A full-time staff with fourteen members is maintained in the Philadelphia office.

Twenty-three thousand, three hundred abstracts were published last year. This number is expected to increase in 1945, with a great post-war increase anticipated when accumulated literature becomes available from abroad.

Present officers of the Board of Trustees were re-elected as follows: *President,* Dr. A. F. Blakeslee, Smith College; *Vice-president,* Dr. E. G. Butler, Princeton University; *Treasurer,* Dr. D. H. Wenrich, University of Pennsylvania; *Secretary,* Dr. Robert Gaunt, New York University.

Present board members re-elected were: Howard P. Barss, U. S. Department of Agriculture; Dr. R. E. Cleland, Indiana University, and Dr. E. G. Butler, Princeton University.

THE TWENTY-FIFTH ANNIVERSARY OF THE AMERICAN METEOROLOGICAL SOCIETY

THE war's weather problems, particularly those related to flying, held the spotlight during the twenty-fifth annual meeting of the American Meteorological Society, which was held at Kansas City on January 24, 25 and 26. High ranking meteorological officers of the Army and Navy were among those in attendance. Canada, Latin America and Russia were also represented. The free-for-all discussion of problems facing forecasters for aviation the world over not only resulted in a general appreciation of the diverse demands on meteorological service, but also brought out helpful suggestions on how to adapt successful experience in one theater to another. The general tenor of the meeting was that of an official international, yet completely informal, round table conference.

Significant of the relation of meteorology to the war is the fact that it was the increased interest in the subject generated by World War I that led to the demand for an American Meteorological Society. In 1919, Sergeant P. W. Etkes, a graduate of the School of Meteorology of the Signal Corps, wrote to his former instructor, Dr. Charles F. Brooks, expressing the generally felt need for a meteorological society. Dr. Brooks carried this idea forward[1] to the organization of the society and its affiliation with the American Association for the Advancement of Science at the St. Louis meeting in December, 1919.

The demand of the present war for meteorological services has led to a great expansion of the membership and activities of the society. In 1920 the society completed its first year with about 900 members. The membership dropped to about 600 by 1927, but with the growth of airways, climbed back to 900 by 1937 and reached 1,200 in 1939. The war has carried the membership to 1,600 in 1943 and over 2,500 in 1944. So strong a professional group has grown up that the society has just instituted a professional class of membership, and is developing postwar expansion of meteorological opportunities, chiefly industrial applications.

In 1920, the society began the publication of its monthly *Bulletin* which at first included less than 200 pages a year of articles, notes, news, announcements, reviews, etc. The *Bulletin* has grown gradually to some 430 pages a year. The editors have been Charles F. Brooks, sixteen years; B. M. Varney, one year; R. G. Stone, eight years. The *Bulletin* now has a paid circulation of more than 4,000.

For some time the need had been felt for a journal devoted entirely to the publication of more or less advanced meteorological research, and in 1944 the society, under the leadership of its president, Professor C.-G. Rossby, director of the department of meteorology of the University of Chicago, undertook the publication of a quarterly *Journal of Meteorology.* This is being edited by Professor Victor P. Starr, of the department of meteorology at Chicago.

Beginning in 1934 with a series of articles by Jerome Namias in the *Bulletin,* editor R. G. Stone brought out a publication called "Introduction to the Study of Air Mass Analysis," which went through five editions, giving students of meteorology nearly 20,000 low-priced books expounding the air mass analysis methods which had developed since World War I.

From its first year, the society has fostered the distribution of meteorological publications not its own. It now has a Book Service which obtains for its members meteorological publications from all over the world, both purchases and library loans. Readers of the *Bulletin* are kept informed of what is being published by a bibliographical department where current publications together with abstracts are listed in classified form.

The society from its beginning has been hemispherical in scope, always having a considerable number of Canadian and Latin-American members. Two of its

[1] SCIENCE, August 22, 1919.

presidents have been Canadians; and Canada and Latin America have been continuously represented on the council. Occasional articles in Spanish have been published in the *Bulletin*, and there are local branches of the society in Latin America.

In large measure the continued functioning and development of the society during these first twenty-five years have been due to the efforts of its secretary, Charles F. Brooks.—R. W. B.

AWARDS OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

THE James Douglas Gold Medal of the American Institute of Mining and Metallurgical Engineers was awarded on February 20 at the New York meeting to Dr. Robert Franklin Mehl, director of the metals research laboratory of the Carnegie Institute of Technology, Pittsburgh, and head of its department of metallurgical engineering, in recognition of "distinguished achievement in physics and physical metallurgy and especially for his development of gamma-ray radiography and for conspicuous success in his metallurgical investigations involving diffusion and crystal structures."

The Robert W. Hunt Silver Medal and Certificate for 1945 was awarded to E. Chester Wright, chief metallurgist of the National Tube Company, Pittsburgh, for improving the process of making Bessemer steel.

The J. E. Johnson, Jr., award was conferred on Carl Gustav Hogberg, assistant to the chairman of the Blast Furnace Committee of the U. S. Steel Corporation, in recognition of "his contributions to the science and art of smelting iron ores in the blast furnaces."

William Marsh Baldwin, Jr., chief metallurgist of the Chase Brass and Copper Company, Euclid, Ohio, received the 1945 award of the Institute of Metals Division for research work leading to the improvement of methods of production of brass cartridge cases.

SCIENTIFIC NOTES AND NEWS

BRIGADIER GENERAL DAVID SARNOFF, president of the Radio Corporation of America, made the principal address at a dinner in New York City on February 18 in honor of Wendell Willkie. On this occasion he was presented with the "One World" award in recognition of his "expansion of radio as a medium for popular education and entertainment, his work on the final reparations settlement in 1929, his contributions to television and his overseas services as special consultant to the Communications Branch of the Public Relations Office, Supreme Headquarters of the Allied Expeditionary Force."

DR. CLIFFORD COPLAND PATERSON, F.R.S., has been awarded the Faraday Medal by the British Institution of Electrical Engineers, in recognition of conspicuous services in the advancement of electrical science.

THE award for outstanding service to chemistry of the Pittsburgh Section of the American Chemical Society "for work worthy of note toward increasing chemical knowledge, promoting industry, benefiting humanity or advancing the Pittsburgh Section" was presented on February 15 to Dr. Leonard Harrison Cretcher, assistant director of the Mellon Institute and head of the department of research in pure chemistry.

THE St. Louis Section of the American Chemical Society has awarded its gold medallion to Dr. Lucas P. Kyrides, research director of the Division of Organic Chemicals of the Monsanto Chemical Company. The medallion is awarded annually for the most "meritorious contribution to the advancement of pure or applied chemistry or of chemical education." The presentation will take place at a dinner to be given on March 5.

DR. THOMAS A. JAGGAR has been awarded the Franklin L. Burr Prize of $1,000 of the National Geographic Society. This prize was established under a bequest of the late Mary C. Burr, of Hartford, Conn., who bequeathed a fund to the society in memory of her father. It provides for cash prizes to members of the expeditions of the society considered by its Board of Trustees to have accomplished especially meritorious work in the field of geographic science. The award was made to Dr. Jaggar, now a resident of Honolulu, Hawaiian Islands, for his part in the development of the first "Duck" or amphibian mobile boat in 1927, which was used by him in 1927 and 1928 to carry on researches in Alaska in the region of the Pavlof Volcano.

PROFESSOR MARSTON TAYLOR BOGERT, emeritus professor of organic chemistry of Columbia University, president of the International Union of Chemistry, has been elected to honorary membership in the American Institute of Chemists.

DR. FRANCIS CARTER WOOD, professor emeritus of pathology at Columbia University, director of pathological laboratories and of radiotherapy at St. Luke's Hospital, in recognition of his fifty years of service as a member of the hospital staff was the guest of honor at a tea given at the hospital on February 14. On this occasion his portrait, painted by Leonibel Jacobs, was unveiled by Lincoln Cromwell, president of the hospital.

UNDER the auspices of the C. W. M. Poynter Foundation of the College of Medicine of the University of Nebraska, an oil portrait of Dr. Poynter, since 1929 dean of the college, painted by Edgar Miller, of Chicago, was unveiled on February 14 and presented to the university. At this time announcement was made of the Poynter Fellowship in the Medical Sciences, also sponsored by the foundation. Following the presentation there was an informal reception honoring Dr. and Mrs. Poynter.

AT a recent meeting in New York City of the American Division of the Club for Research on Ageing the following officers were elected for the ensuing year: *Chairman,* Dr. Wm. deB. MacNider; *Secretary,* Dr. Edward J. Stieglitz; *Executive Committee,* Dr. E. V. Cowdry, *chairman,* Dr. Joseph C. Aub and Dr. A. Baird Hastings.

DR. MARGARET CAMMACK SMITH, since 1925 head of the department of human nutrition in the Agricultural Experiment Station of the University of Arizona, will retire from active service on June 30.

DR. E. A. CULLER, of the University of Rochester, who is retiring as chairman of the department of psychology, will continue his work as professor of psychology and director of the Hearing Laboratory.

A. I. LEVORSEN, research geologist of Tulsa, Okla., and past president of the American Association of Petroleum Geologists, has been appointed professor of geology and executive head of the department at Stanford University.

DR. WALTER L. HARD, of the department of histology of the School of Medicine of the University of Maryland, has been appointed assistant professor of anatomy at the Medical College of the State of South Carolina.

LIEUTENANT COLONEL B. G. MAEGRAITH, in charge of the British Army Malaria Research Unit, has been appointed Alfred Jones professor of tropical medicine at the Liverpool School of Tropical Medicine. He succeeds the late Professor Warrington Yorke.

WESTERN RESERVE UNIVERSITY has received from Wyeth, Incorporated, of Philadelphia, pharmaceutical and biological manufacturers, a gift of $12,600 to conduct studies of toxins and antitoxins in order to determine more closely their active principles. The work will be carried on by Dr. Louis Pillemer, research immunologist of the Institute of Pathology of the university, under the direction of Dr. E. E. Ecker, professor of immunology.

Nature reports that Dr. Eric Ashby, professor of botany in the University of Sydney, has been appointed scientific attaché, with the rank of counsellor, to the Australian Legation in Moscow. Professor Ashby's appointment, which is for about a year, has been made in order to establish contact with leaders of science in the U.S.S.R., and particularly with those working on problems of mutual interest to that country and Australia.

DR. W. P. MARTIN, since 1937 assistant professor of biochemistry at the University of Arizona, has resigned effective on March 1 to become associate soil chemist at the U. S. Regional Salinity Laboratory at Riverside, Calif.

DR. R. K. LARMOUR, professor of chemistry at the University of Saskatchewan, has been appointed director of the Prairie Regional Laboratory of the Canadian National Research Council which is to be built in Saskatoon. The laboratory will be concerned primarily with investigations into the utilization of agricultural crops and will be provided with facilities to undertake all phases of laboratory and pilot investigations in this field.

MAJOR G. J. DAMMIN, M.C., has returned to the continental United States. He has completed a mission in the India-Burma theater as executive officer for the Dysentery Commission of the Army Epidemiological Board and now has been assigned to direct the Division of Laboratories in the Surgeon General's Office.

DR. L. J. STADLER, geneticist of the Missouri Agricultural Experiment Station, spoke on February 19 at Iowa State College on "Gene Mutation." The lecture was given under the auspices of the Research Council.

THE annual lecture of the Wayne University Chapter of the Society of the Sigma Xi was delivered on February 27 by the Reverend Dr. James B. Macelwane, S.J., director of the Institute of Geophysical Technology of St. Louis University. The subject of the lecture was "The Interior of the Earth."

DR. PAUL J. FLORY, of the research laboratory of the Goodyear Rubber Company, addressed the Southeastern Pennsylvania Section of the American Chemical Society on February 22.

THE Office of Defense Transportation has refused authorization to hold the annual meeting of the Federation of American Societies for Experimental Biology on May 8, 9 and 10, 1945. Therefore the meeting will be cancelled. The federation is composed of the American Physiological Society, the American Society of Biological Chemists, the American Society for Pharmacology and Experimental Therapeutics, the American Society for Experimental Pathology, the American Institute of Nutrition and the American Association of Immunologists.

APPLICATIONS for grants from the Cyrus M. Warren Fund of the American Academy of Arts and Sciences should be received by the chairman of the committee, Professor Frederick G. Keyes, Massachusetts Institute of Technology, Cambridge 39, Mass., not later than April 16. Grants are made in aid of chemical research—generally for apparatus or supplies or for the construction of special facilities needed for research in chemistry or in fields closely related to chemistry. Grants are not awarded for salaries, and, on account of limited resources, the amount to an individual is seldom in excess of $300. Application blanks may be obtained from the chairman upon request.

SIX fellowships for graduate students, each calling for a stipend of $1,200 annually, have been established at the University of Chicago in honor of William Rainey Harper, its founding president. The fellowships are open to any student with a master's degree or its equivalent, who wishes to work for the degree of doctor of philosophy, either at the University of Chicago or elsewhere.

THE Canadian National Research Council has installed the latest type of electron microscope in its laboratories at Ottawa. This instrument and one developed in the department of physics of the University of Toronto are the first electron microscopes to be used in Canada. A third microscope will be installed at McGill University. The council plans to make the microscope as widely available as possible to all government laboratories and to those industries having suitable problems. The Electron Microscope Society of America has been formed to aid in the exchange of information on microscope techniques and experimental results.

THE Seventh Addendum to the British Pharmacopoeia, 1932, was published under the direction of the General Council of Medical Education and Registration of the United Kingdom on January 30, and became official from that date.

DATA for maps, secretly moved from Manila to Corregidor and then picked up by a submarine for delivery to an American base, were used in the preparation of the new map of the Philippines of the National Geographic Society, which will be a supplement to the March issue of the *National Geographic Magazine*. Printed in seven colors, the map shows most of the 7,083 islands and isles. Three thousand seven hundred and eighty-seven places are named, and railroads, highways, mountain heights and swamplands are indicated.

MRS. MARY-RUSSELL F. COLTON, one of the trustees of the Museum of Northern Arizona, on the occasion of the seventeenth annual meeting, presented the institution with about ten acres of land on which are a number of masonry and frame buildings. The gift adjoins other property owned by the museum and brings the total holdings to seventy acres. When the new buildings are remodelled, they will provide greatly increased space for research. The Museum of Northern Arizona is situated three miles north of Flagstaff, at the base of the San Francisco Peaks (altitude 12,640 feet). In the past the museum has provided, each summer, research facilities for a few advanced students in geology, anthropology and biology. In the post-war period it is hoped that this service may be greatly increased.

ACCORDING to the daily press, Washington University, St. Louis, will receive under a decision of the Appellate Court $1,250,000 for a geophysical technological institute from the estate of Henry E. Sever, Chicago publisher. The decision reverses a ruling by Judge Joseph A. Graber, of the Cook County Superior Court, that the money should go to St. Louis University.

THE University of Rochester plans to expand its program for engineering students under a newly established Division of Engineering in the College of Arts and Science. The new division is a development of the Department of Engineering and will have much of the freedom of action usually associated with a separate school. It is being set up in anticipation of a greatly increased demand for engineering training after the war, as well as to meet present needs. A new four-year course in electrical engineering is planned in addition to the present accredited programs in chemical and mechanical engineering.

DISCUSSION

THE TORQUE OR ROTATING ACTION IN A BEAM OF LIGHT

RECENTLY before the American Physical Society in New York, Felix Ehrenhaft gave a paper in which he claimed that he had proved that a beam of natural (unpolarized) light produces a rotating action on matter on which it falls; that the idea was entirely new, never before entertained by physicists and never demonstrated. As he regarded himself to be a lone pioneer in this topic he naturally gave no historical references.

Here are some facts connected with this topic. In my text, "An Elementary Survey of Modern Physics" (Macmillan, 1936), pages 57, 424, 425, I have dis-

cussed the torque in a beam of *circularly polarized* ight. There it is pointed out that Professor Poyn- ing of Birmingham in 1909, basing his ideas on the ave theory, worked out the torque T to be expected or a circularly polarized beam of one square centi- neter as $T = M\lambda/2\pi$ where M is the energy density, herefore the pressure, and λ is the wave-length. I hen present the argument based on the idea of pho- ons and arrive at the same result.

These views had been presented to my classes for ome years before the publication of my text in 1936. But I did not know that A. Sadowsky in Russia had derived a similar result, basing his work on Maxwell's heory.[1]

Now the pressure of light on an absorbing surface n the experiments performed by E. F. Nichols and myself was of the order of 10^{-7} gram per cm^2. Hence theory gives for the torque in a beam of 1 cm^2 cross section an amount of about 5×10^{-12} gm cm or 0.000,- 000,000,005 (the last digit is of no significance except to show its approximate decimal position) gm cm. This almost infinitesimal amount however is for an in- tense beam, one square centimeter in cross section of *circularly polarized light*. For a beam of natural or plane polarized light the torque would be exactly zero on either theory. For a beam of light of two one hun- dredths of a centimeter in diameter of such an in- tensity that it could be observed in a microscope, the torque, even in the case of circularly polarized light, would be about one millionth of the amount given above or 0.000,000,000,000,000,005 gm cm. For nat- ural light it would be zero.

But though the torque to be looked for in a beam of circularly polarized light (for elliptically it would be less, for plane polarized or natural it would be zero) is extremely small, it can and it has been detected. In my book, page 425, I outlined the ex- perimental method. The experiment, independently devised, was performed by Richard A. Beth[2] in Prince- ton. He showed extraordinary courage in attempting to measure this minute quantity. The experiment called for prolonged and intense labor and was carried out with excellent technique. He obtained a result of the right order of magnitude as given by the theory. Beth's experiment was not of the show-off kind. He didn't call in the villagers to see the phenomenon "that was going to revolutionize our ideas of the universe." His work and the work of the theoretical physicists who have considered this matter show that the rotating action in a beam of circularly polarized light is ex- ceedingly small and in a beam of natural light nothing whatever.

GORDON FERRIE HULL
DARTMOUTH COLLEGE

[1] A. Sadowsky, *Acta et Commentationes Imp. Universitatis Jurievensis*, 7: No. 1–3, 1899; 8: No. 1–2, 1900.
[2] *Phys. Rev.*, 48: 471, 1935; 49: 411, 1936; 50: 115, 1936.

TEMPERATURE INDUCED STERILITY AND EVOLUTION

IN an over-simplified form the following discussion presents an analysis of a few possibilities that seem to be inherent in a thermal sensitivity of male germ-plasm.

All terrestrial animals that have been investigated with respect to temperature tolerance of the male germ-plasm have shown that applications of heat will produce some degree of infertility. The effects range from lowered fertility to complete sterility. It is notable that in some instances normal body tempera- tures of warm-blooded animals will cause sterility and that somewhat comparable conditions exist in the cold-blooded animals.

The process of evolution from amphibia to the mammals and birds, the latter having the highest known vertebrate temperatures, displays the progres- sive adoption of ever-higher temperatures, and it is therefore remarkable that in no known instance are the mammalian testes invulnerable to exposure to high temperature. It would seem inevitable that in the long course of a history of rising temperature, the warm-blooded animals would have established testicu- lar temperature tolerances compatible with their somatic requirements. There does not yet seem to be any known case of a balanced body-germ-plasm tem- perature harmony in any group of the vertebrates, although it is logical to expect that there would have been some such perfection. The absence of such information may, of course, result from the fact that there has as yet been no search for such an adjust- ment.

The entire picture seems to be one of a steady somatic advance in utilization of high temperatures with failure of the spermatogenic mechanism to keep up with advance. It is as though the body paced the advance while the germ-plasm acted as a retarding influence.

It also seems clear to me that any failure of the germ-plasm to maintain at least a reasonable tolerance to an advance in the body temperature would en- danger the entire complex of the fecundity-mortality balance. A diminution in the reproductive capacity, resulting from heat exposure following such a disloca- tion, could result in catastrophe to the gene complex allowing the dislocation.

That the scrotal mammals have circumvented this disaster by the purely fortuitous acquisition of a novel, essential, thermoregulatory device is definitely established, as is the fact that non-scrotal forms ap- pear to detour their dilemma by various expedients such as a retention of a poikilothermous temperature fluctuation during spermatogenesis, or by not having acquired the high temperature of the more specialized mammals. It seems possible that the opportunist type of expedient, namely, intermittent spermatogenesis

occurring only when body temperatures are lowest, may characterize some birds.

The ectotherms (poikilotherms) have not lost the advantage of a freely fluctuating temperature, but in almost all known cases their reproductive activity is suspended during hot weather and there is a notable regression in the size of the testes which is ordinarily not reversed until the appearance of cool weather. Spermatogenesis like all cellular activity is merely slowed or suspended, but is not destroyed by the effects of cold.

Until recently nothing definite has been known concerning reptilian testicular reactions to high temperatures, but a forthcoming paper to appear in the *American Naturalist* demonstrates that these animals also fit the picture, thus completing a rough sketch of the responses in the terrestrial organisms.

From my standpoint this apparently universal weakness in the thermal accord between somatic and germinal tissues must have played a very dramatic role in evolution and could very well have been responsible for the extinction of many groups of organisms. The necessary heat stresses could have resulted from climatic change alone in some instances, a possible example being that of the dinosaurs, or through the development of poorly coordinated somatic-germinal heat progress or through a combination of these factors. Other possibilities will be suggested in the account scheduled for appearance in the *American Naturalist*.

A review of many of the articles pertaining to this subject will be found in Allen's "Sex and Internal Secretion," in the sections dealing with the testes. A more complete citation of sources is not compatible with the present space limitations, but will accompany the more detailed report.

RAYMOND B. COWLES

UNIVERSITY OF CALIFORNIA,
LOS ANGELES

"STARRING" IN AMERICAN MEN OF SCIENCE IN RELATION TO THE STATUS OF CHEMISTRY

ACCORDING to the National Roster of Scientific and Professional Personnel,[1] chemists not only outnumber each of the other types of scientists by at least a ratio of seven to one, but they outnumbered by nearly 40 per cent. all other scientists taken together.

Since these figures appear to be startling it seems desirable to go to other sources for further information. On the basis of sampling 20 pages of listings taken at random from the seventh edition of "American Men of Science" it appears that the ratio between chemistry and its nearest competitor, physics, is a little more than 2 to 1, and that about 23 per cent. (about 7,500) of the total listings are chemists. This would make the non-chemists outnumber the chemists by about 3 to 1. This does not agree with the National Roster data, which would indicate a ratio of about 0.7 to 1.

The difference between these two sets of figures is probably due almost entirely to the fact that large numbers of chemists are employed in industry and many of these do not publish scientific articles and hence are not listed in "American Men of Science." Many are engaged in industrial research and are "men of science" in a real sense. Purely routine jobs in chemical industries are more often done by those who are trained for a particular operation, but who have no professional training in chemistry.

This interpretation is borne out by the statistics given in the report of the National Research Council to the National Resources Planning Board.[2] Of all the professionally trained research personnel in industry 15,700 or about 43 per cent. are chemists. If the engineers are excluded, the chemists constitute 72 per cent. of the total, well over ten times the number of its nearest competitor. It should be noted that the number of professionally trained chemists engaged in industrial research (15,700) is about twice the total number of chemists listed in "American Men of Science."

In 1941 and 1942 listings of doctorates in science[3] indicate that chemists, including biochemists, outnumber their nearest competitors (physicists) by more than 4 to 1. The non-chemist doctorate degrees in science outnumber the doctorates in chemistry by about 2 to 1. In the 1944 listing[4] doctorates in chemistry and biochemistry constitute 51 per cent. of the total.

Another method of arriving at the status of the different sciences is to consider membership in the respective professional societies. The major societies in the fields indicated have, according to the latest information available,[5] total memberships as follows: chemistry 29,552 (95 per cent. in the American Chemical Society); physics 7,067; geology 8,177; botany and bacteriology 7,323; zoology 14,118 (scattered in 12 societies). Chemistry membership outnumbers its nearest rival, zoology, about 2 to 1 and is about 45 per cent. of the total in these fields.

The large membership in chemistry exists in spite

[1] SCIENCE, 96: 292, 1942.

[2] "Research—A National Resource." II. "Industrial Research," p. 176. Washington, D. C.: U. S. Government Printing Office. 1941.

[3] E. A. Henry, SCIENCE, 99: 431, 1944.

[4] "Doctoral Dissertations Accepted by American Universities," No. 11, 1943–44, New York. H. W. Wilson Co. 1944.

[5] Compiled from Handbook of Scientific and Technical Societies and Institutions of the United States and Canada, fourth edition. Bulletin 106, National Research Council. Washington, D. C. 1942.

of dues ($9.00 without journals[6]), which are higher than average. The relatively large membership in the societies representing the various branches of zoology is accounted for in part by low dues (average about $3.00) and the fact that there is undoubtedly a large amount of overlapping membership.

The starring of chemists in "American Men of Science" is wholly out of line with the data which have been presented. The numbers of the various scientists first starred in "American Men of Science" in the seventh edition, as well as earlier editions, are as follows[7]: chemists 44; physicists 37; zoologists 37; geologists 27; botanists 25; mathematicians 21; pathologists 15; astronomers 13; psychologists 13; physiologists 11; anatomists 7; anthropologists 5. If we accept the other numbers (taken as a group) as a standard, the number of chemists who should have been starred (leaving out of consideration past deficiencies) is about 58 if the total listing in "American Men of Science" is used as a basis or about 295 if the National Roster figures are used. Possibly an intermediate figure of 106 based upon doctorate degrees in 1941 and 1942 would be more nearly fair.

From these facts one may conclude that chemists have not been good salesmen or advertisers. The matter of starring is but one aspect of the larger problem of improving the status of chemistry. It is hoped that before the eighth edition of "American Men of Science" is published, this problem, including that of accumulated deficiencies, will be considered fully.

ROGER J. WILLIAMS
THE UNIVERSITY OF TEXAS

MOLD PREVENTIVE FOR BOOK BINDINGS

IN warm climates following a protracted rainy spell, it is not uncommon to find one's book bindings supporting a heavy growth of mold, which if unchecked will disfigure the books. Mere dusting removes the superficial growth without disturbing the mold actually growing in the paste of the bindings.

Several years ago, following a wet season, the Duke Hospital Library had an epidemic of mold in two stacks of bound journals which stood near an underground ventilator drawing air from an open areaway. The author was called upon for suggestions to remedy the situation. The vent was closed and the following solution was wiped over the molded bindings:

Thymol crystals	10 grams
Mercuric bichloride	4 grams
Ether	200 cc
Benzene	400 cc

The treated volumes have never shown any tendency to mold since and any other outbreaks of mold have been similarly and effectively treated. The solution is poisonous and inflammable and should be used carefully in an open room or outdoors with no source of fire near by. It is best applied with a cotton sponge tied to a suitable applicator or held by forceps, so that none of it gets upon the fingers. The solution penetrates the bindings readily and dries rapidly, leaving no precipitate. One application is usually sufficient and the books may be returned at once to their places. It is wise to test first one corner of the binding before using the solution to discover whether the dye may run or change in any way. In our experience it has not altered the appearance of the goods nor affected the letter stampings.

The solution may, as well, be safely used on record album backs, leather boxes and luggage, but it should *never* be used on any wearing apparel.

DUNCAN C. HETHERINGTON
DEPARTMENT OF ANATOMY,
DUKE UNIVERSITY SCHOOL OF MEDICINE,
DURHAM, N. C.

FANCIFUL PORTRAITS OF ANCIENT MATHEMATICIANS

IN his "Works of Archimedes" (1897) T. L. Heath (1861–1940) remarked in the preface: "I have had one disappointment in preparing this book for the press. I was particularly anxious to place on or opposite the title-page a portrait of Archimedes." He then added that he was reluctantly obliged to abandon this plan because he could not find a reliable portrait of Archimedes after a careful search. He evidently thought it was better not to include any portrait of Archimedes than to insert a fictitious one. On the contrary, a considerable number of our mathematical text-books include fictitious portraits. Even Volume I of D. E. Smith's "History of Mathematics," which is widely used in our schools, includes such portraits.

In his review of this volume, published in *Isis*, Volume 6, page 443 (1924), George Sarton remarked: "The inclusion of fanciful portraits (for example, of Plato and Fibonacci) seems to me a serious mistake for which I can find no justification." Fortunately, the second volume of D. E. Smith's "History of Mathematics" does not contain such portraits, but they were then still widely advertised as suitable for the walls of mathematical classrooms, where they naturally mislead many students as regards the history of our subject unless it is plainly noted that they are unreliable. Even then they are frequently misunderstood.

As definite evidence of the existence of such portraits in influential mathematical text-books we may refer to the revised edition of the plane geometry by Slaught and Lennes (1918). We find here such portraits of Plato, opposite the title-page; Euclid, opposite page 66; Pythagoras, opposite page 236; and

[6] These dues have since been lowered to $7.50, but this did not affect the 1942 data.
[7] J. Cattell, SCIENCE, 100: 126, 1944.

Archimedes, opposite page 272. In none of these cases is it stated that these portraits are fanciful. It is true that historical material, including portraits of mathematicians, is usually of secondary importance in a mathematical text-book and may be omitted entirely, but when it does appear therein it should be reliable in order to inspire the student with due confidence and cultivate high ideals as regards truth.

Fanciful portraits of the same mathematician may naturally differ very widely, and this wide difference sometimes discloses nothing in regard to the known characteristics of the individual concerned. According to the *Bulletin of the American Mathematical Society,* Volume 40, page 189 (1934), under the heading "International Mathematical Congress Medals," an international committee was appointed to decide on awards to be made at the Oslo Congress (1936). The task of designing a suitable medal was entrusted to a Canadian sculptor who completed a medal showing a fanciful head of Archimedes, one of the greatest mathematicians of antiquity.

Since it was then well known that no reliable portrait of Archimedes was extant recourse was had to a collection of over thirty fictitious portraits then owned by D. E. Smith (1860–1944) and placed by him in the library of Columbia University. These show the views of many different artists and differ widely from each other. This procedure may be of interest to some who do not believe that the results obtained thereby have much scientific value. It is also of interest because it was used by such a large body of mathematicians, including some of the most noted at that time, and hence may appear to exhibit a widespread indifference as regards mathematical history.

The appearance of a considerable number of fanciful portraits in our elementary mathematical text-books is an element of the American history of mathematics which seems to have as yet received little attention. In fact, the history of the development of mathematics in our country has as yet received little attention. Important beginnings along this line were made by F. Cajori's work entitled "The Teaching and History of Mathematics in the United States" (1890) and by the small volume due to D. E. Smith and Jekuthiel Ginsburg, entitled "A History of Mathematics in America Before 1900." The former was published by the U. S. Bureau of Education and the latter by the Mathematical Association of America in 1934.

G. A. MILLER
UNIVERSITY OF ILLINOIS

SCIENTIFIC BOOKS

RADIO'S MEN OF SCIENCE

Radio's 100 Men of Science. By ORRIN E. DUNLAP, JR. New York: Harper and Brothers. 1944. $3.50.

To paint word portraits of the hundred men who have contributed most to radio is indeed no small task, but the author has succeeded in producing a profoundly interesting story and, within the limits dictated by space, he has given as full an account of the achievements and personalities concerned as could reasonably be expected. The result is a book which is full of interest from beginning to end.

Naturally, when one spreads the development of radio over a hundred individuals, there is likely to be ample room for divergence of opinion as to the appropriate choices which have been made. This is more particularly the case since many of the individuals named have paid their contribution, not to radio directly, but rather to some piece of apparatus or device which ultimately found its use in that field, but which was not invented with wireless primarily in mind. In those fields which pertain more particularly to radio itself, one might question the omission of certain names having to do primarily with measurements of the Kennelly-Heavisidean Layer and of the complex nature of the layer.

It would be out of place to make too much of minor points of technical criticism, but the elementary student of physics is so frequently castigated for failing to realize that Ohm's Law implies merely a proportionality between voltage and current, that one is rather concerned to find the sin for which he is so castigated supported in the citation of Ohm's Law given on page 34, to the effect that "A current flowing in any closed circuit is proportional to the force or voltage and inversely proportional to the resistance of the wire."

The author is to be congratulated upon having accomplished a very worth-while task and on having produced a book which is not only informative, but one which should serve as an inspiration to many young people whose ambitions urge them to simulate the outstanding inventors of the science of radio.

W. F. G. SWANN
BARTOL RESEARCH FOUNDATION,
SWARTHMORE, PA.

ELECTRICAL COMMUNICATION

Electric Circuits and Fields. By HAROLD PENDER and S. REID WARREN, JR. 509 pp. Illustrated. 8½ by 5¼ inches. New York: McGraw-Hill Book Company. First edition. 1943. Cloth, $4.00.

THE rapid development of electrical communication

has radically changed the study and teaching of electrical engineering. Most early books on alternating current circuit theory considered the question solely from a standpoint of constant frequency and maximum efficiency, and newer texts were written for communication circuits covering the range of frequencies then in use. A still more recent development is the use of ultra-high frequencies for wave guides, radar, etc., and this calls for a still different treatment. The consequent increase in scope and amount of material in the field is being reflected even in the elementary courses. The time allotted to undergraduate preparation remains unchanged, and, as a result, the basic courses must prepare the student for specialization in either power or communication.

Dean Pender and Professor Warren attempt to solve this problem by presenting the theory of electric circuits and fields in a way which will be basic for any type of contemporary problem. The content and approach of this book are the outgrowth of a two-term course taught over a period of years at the Moore School of Electrical Engineering of the University of Pennsylvania. The purpose is to cover the whole field in a rigorous but limited manner so that subsequent advanced courses are well correlated. In order to accomplish this purpose some material is omitted, *viz.*, the actual operation of solving a differential equation, and only the results presented. However, all the conditions and limitations are carefully stated, and the material can be supplemented by reading the references in the bibliography at the end of each chapter. Particular care has been used to be consistent, and the rationalized M.K.S. system of units has been used throughout.

Two points of view are presented—the first, covering circuits in which current is confined to discrete circuit elements, and second, three-dimensional cases where the fields must be specified throughout a considerable region in space. Part I (229 pages) considers circuits of lumped constants through direct current nets, simple network theorems, transients, alternating currents, complex numbers, polyphase circuits and symmetrical component, filters and transmission lines and non-linear circuits. Part II (200 pages) covers electric fields and capacitance, magnetic flux and effects, electron ballistics and electron apparatus and electromagnetic radiation. Five appendices cover briefly the solution of linear differential equations with constant coefficients, three-dimensional vector analysis, electric fields for cylinders and vector potentials for magnetic phenomena.

There are many features to recommend this book, but its greatest value lies in its coordinated and balanced coverage of a large and complex field. The references and representative problems make it possible to supplement the text to satisfy the needs of any individual with a background of calculus and general physics.

A. E. VIVELL

SWARTHMORE COLLEGE

PHOTOMICROGRAPHY

Photomicrography—Theory and Practice. By CHAS. P. SHILLABER. 5½ × 8½. 773 pp. 34 tables. 291 figures. Bound in blue buckram. New York: John Wiley and Sons. 1944. $10.00.

To a certain extent, the ability of a microscopist may be judged by the quality of his photomicrographs. While it is true that interpretation in terms of the solution to a more general problem is equally important, a photomicrograph certainly indicates the ability of the microscopist to operate the microscope correctly. The quality and optical characteristics of the lenses, the type of illumination employed, the preparation of the specimen, the magnification, the photographic variables of film type, exposure, etc., and many other equally important factors must all be intelligently selected if the photomicrograph is to illustrate credibly the relevant features of the specimen.

It is not surprising that a book which covers this subject contains over 700 pages. "Photomicrography" is more than a "cook-book" for taking pictures through a microscope. Even the microscopist who takes no pictures will still benefit from this book, since most of the information contained therein not only can, but should be used in visual microscopy.

The book is written with a minimum of technical terms. Those which must be used are explained in the first chapter. In addition, a glossary of microscopical and optical terms is included. At the close of seven of the eight chapters, there are questions and laboratory experiments which should prove useful to both the teacher and beginner.

The three chapters on the optics of the microscope are rather long and this may discourage the casual microscopist. However, the frequent and illustrative diagrams will be found helpful in grasping these fundamentals. Some 16 pages are devoted to listing the optical constants of objectives made by various manufacturers. Information of this sort can usually be obtained from catalogues and to this reviewer such tables unduly increase the size of the book.

The chapter on light filters and glare is important and well presented. The author's description of the troublesome effects and sources of glare is especially commendable.

Descriptions of photomicrographic cameras and photosensitive materials are combined in one chapter. Pictures of commercially available cameras, including those for special purposes, such as the Jelly spectrographic camera, are included. The brief discussion

of photography describes such factors as the speed, gamma, graininess and color sensitivity of the photographic plate, and typical formulas for developers, short-stops and fixing baths.

The chapter on specimen preparation deals mainly with those mounting media which are used when the image is obtained by transmitted illumination. A few typical formulas for staining solutions are presented. At the end of this chapter, a table of 14 pages describes various etching reagents for most of the common metals.

In the final chapter many typical problems of photomicrography and their solution are presented. This chapter contains over half of the 140 photomicrographs in the book. The use of several photomicrographs of the same field to show the effect of different variables is highly commendable. The pertinent information on the equipment, illumination, film, etc., used to obtain the picture, as well as a schematic diagram showing the position of the light sources, is given for most of the photomicrographs.

As the author himself indicates in his prefatory remarks, the book suffers by the omission of such subjects as polarized light, color photomicrography, ultraviolet, infrared and fluorescence microscopy and stereoscopic photomicrography. This will make the book less useful to the experienced microscopist. The author explains the omission as an attempt to avoid undue increase in the size of the book and indicates plans to add information on such subjects at a later date. It is the opinion of this reviewer, however, that portions of the present book might well have been omitted or shortened to make room for such discussion.

In summary, the book is highly recommended for beginners and teachers in the field of microscopy. The experienced worker will want to add it to his library if for no other reason than that it contains in one place a variety of information to which he will constantly refer. A new volume or a revised edition containing information on the less common phases of microscopy and written by such an able writer will be eagerly awaited by all in the field.

W. G. KINSINGER

HERCULES POWDER COMPANY

REPORTS

RESEARCH BOARD FOR NATIONAL SECURITY

THE recently announced Research Board for National Security is the result of recommendations made by a special committee on post-war research appointed by the Secretary of War and the Secretary of the Navy under the chairmanship of Mr. C. E. Wilson and composed of high-ranking representatives of the Army and Navy together with Dr. F. B. Jewett, Dr. H. C. Hunsaker, Dr. Merrill A. Tuve and Dr. Karl T. Compton. This committee recommended the establishment of a joint Army, Navy, civilian board directed to organize and administer a forward-looking program of research in scientific matters pertinent to national security.

It was recommended that this board be composed of ten Army officers of general rank and ten Naval officers of flag rank, and twenty civilians chosen from the fields of science, engineering and industry. This large board is expected to determine general policies and to insure appropriate attention to the wide field of interests of the Armed Services and other possibilities in all pertinent scientific fields. Within the large board there is an executive committee of three civilians plus an Army officer and a Naval officer, each of whom has responsibilities for coordination of research in the respective services.

This board will be concerned with the advancement of science and the development of techniques in those directions which may have profound influence on the conduct of future warfare. It is specifically not intended that this board should participate in the improvement of existing weapons or in other developments which are the function of the various research and development laboratories operating under the War and Navy Departments. It is expected, of course, that there will be ranges of overlap in the period in which a new idea passes out of the research stage through the development stage and into production, and in such cases there will be cooperation in which the Research Board for National Security tapers off its connection with the project as the appropriate branch of the Armed Services takes it on for the final development of a military weapon.

In accordance with the recommendation of the Wilson Committee the Research Board for National Security has been appointed by the president of the National Academy of Sciences at the request of the Secretary of War and the Secretary of the Navy, and the military members of the board have been nominated by these secretaries. The Wilson Committee also recommended attention by Congress to the ultimate establishment of the Research Board for National Security as an independent agency of government, and this question has been before the Select Committee of the House on Post-War Military Policy headed by Judge Woodrum. Pending the decisions regarding permanent organization, the Research Board for National Security will continue as a special agency of the National Academy of Sciences but will operate in such manner that it can be transferred with a mini-

mum of lost motion to any other administrative set-up if this be the decision of Congress.

A great advantage of operation under the National Academy of Sciences is the immediate availability of the enormous resources and contacts of the National Research Council and the support which is inherent in the prestige which the academy and the council have achieved among scientific men and governmental agencies. The Research Board for National Security will plan to utilize the resources of the academy and the Research Council to the fullest possible extent. Another advantage of operating under the National Academy of Sciences is the flexibility inherent in the Congressional Charter of the academy, which provides, "... the Academy shall, whenever called upon by any department of the government, investigate, examine, experiment and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the government of the United States."

In continuing its operations it is probable that the Research Board for National Security will follow substantially the pattern which has been established by the Office of Scientific Research and Development during this war. This pattern has been developed through the aggregate constructive thinking of civilian scientists, Army and Navy officers and government officials with a fine degree of cooperation and understanding in high quarters. It will serve as the best possible starting point for the new post-war organization.

In conclusion a word should be said regarding the relationship between the Research Board for National Security and the Office of Scientific Research and Development during the balance of this war. The Office of Scientific Research and Development is an emergency wartime organization which will be disbanded as soon as its affairs can be terminated after this war. It is devoted solely to scientific developments which show reasonable promise of usefulness in this war. Every one concerned has agreed that the Research Board for National Security shall not, during this war, engage in activities which are the proper function of the Office of Scientific Research and Development or which will in any way detract from the activities of the Office of Scientific Research and Development or any other war agency through competition for the services of personnel or for research facilities which are needed for the prosecution of the war. The Research Board for National Security is definitely a post-war and long-range agency. In order, however, that it may be prepared with some experience to take over from the Office of Scientific Research and Development any important research projects of continuing long-range importance at the time when the Office of Scientific Research and Development is ready to terminate its activities, it is likely that a few non-competitive long-range research contracts will be entered into in the near future so that the Research Board for National Security may be an actual going concern when the time comes for it to become active on a substantial scale.

All evidence to date indicates that this post-war project has hearty endorsement by leaders in government, in the Armed Services and among civilian scientists and engineers. It should be one of the significant factors in maintaining that degree of future preparedness which will help to insure this country against attack and which would equip it to conduct a future war with a maximum degree of effectiveness and a minimum loss of life and of economic cost in case, unhappily, another war is forced upon it. For these reasons the continued support of this enterprise by the public and the wholehearted cooperation of the Armed Services, the civilian scientists and the industrial and academic laboratories is confidently anticipated.

The membership of the Research Board for National Security as initiated constitute the following:

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KIRK, MAJOR GENERAL NORMAN T.
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Chief, Bureau of Aeronautics

KARL T. COMPTON,
Chairman of the Executive Committee

SPECIAL ARTICLES

ORAL PENICILLIN[1]

As a result of Libby's demonstration[2] that appreciable concentrations of penicillin in the serum of dogs and man may be attained following the oral administration of suspensions of penicillin in oil, we have investigated the administration of penicillin by the oral route by four methods. On successive days a series of normal subjects ingested (*a*) penicillin in corn oil, (*b*) penicillin in water, (*c*) penicillin in water preceded by a buffer, and (*d*) penicillin in peanut oil and 4 per cent. beeswax. The penicillin was dissolved in 30 cc of water. Magnesium trisilicate was the buffering agent used. A 4-gram dose was administered every hour for 3 hours before the ingestion of the penicillin. It has been shown[3] that the dosage will raise the pH of the gastric content to approximately pH 8. All subjects were kept in a fasting state throughout the period of observation. Three doses of penicillin, 315,000, 100,000 and 50,000 units, were studied. The bioassays of penicillin were performed by the Rammelkamp method.[4]

Serum concentrations of penicillin which were attained following the ingestion of 315,000 units of penicillin by the four methods described above may be seen in Fig. 1. Penicillin concentrations attained following the intramuscular injection of 300,000 units

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Cornell University Medical College.

[2] R. L. Libby, SCIENCE, 101: 178, 1945.

[3] W. N. Mann, *Guy's Hospital Reports*, 87: 151, 1937.

[4] C. H. Rammelkamp, *Proc. Soc. Exp. Biol. and Med.*, 51: 95, 1942.

of penicillin in aqueous solution are presented for comparison. Each point on the graph represents (as indicated) an average of three or four experiments. As may be seen in the figure, serum concentrations ranging between 0.312 and 1.25 unit of penicillin per cc were present at 30 or 60 minutes after ingestion. It appears that penicillin concentrations of approximately the same order of magnitude are attained regardless of whether the penicillin is given in oil, in oil and beeswax, in aqueous solution preceded by a buffer or in aqueous solution alone.

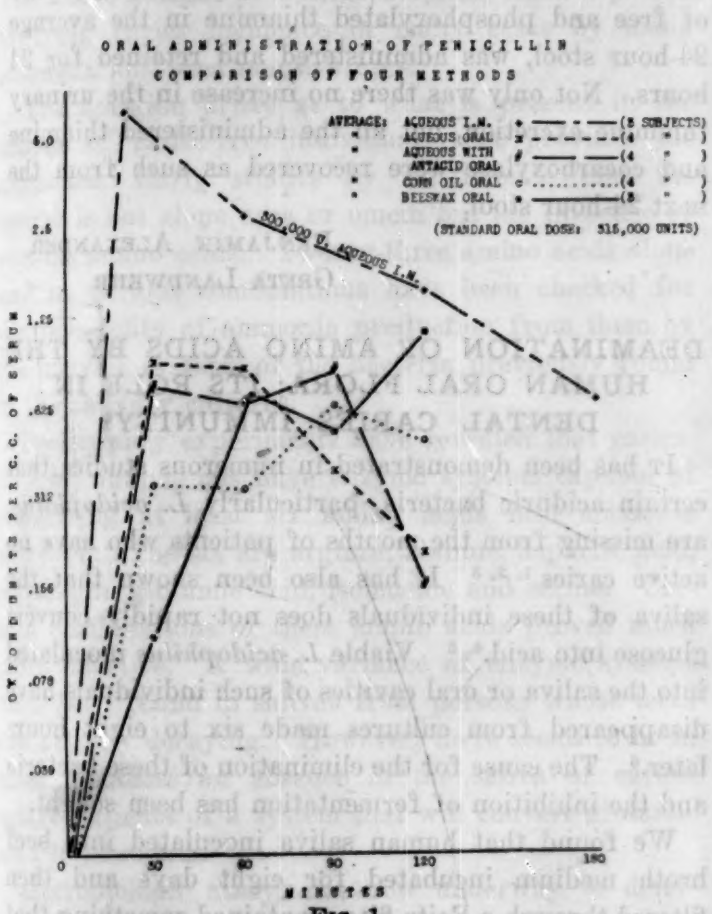

FIG. 1.

The height of the penicillin concentrations at 2 hours after ingestion of the oil and the oil and beeswax preparations suggests that the duration of penicillin action may be prolonged by the use of these vehicles by mouth in a manner similar to the prolongation which Romansky[5] has shown follows the administration of penicillin in oil and beeswax by the intramuscular route.

Only a fraction of the penicillin which was ingested was excreted in the urine during the succeeding 12 hours. The total urinary excretion during this period ranged from 6 to 32 per cent., but in the majority of instances it was approximately 12 per cent. Just as with the penicillin concentrations attained in the blood, there seemed to be no significant difference in the amount of penicillin excreted in the urine after ingestion of the various preparations.

[5] M. J. Romansky and G. E. Rittman, SCIENCE, 100: 196, 1944.

Studies of the serum concentrations and urinary excretion of penicillin following single oral doses of 100,000 and 50,000 units by the four methods described above yielded results which were qualitatively similar to those observed after the 315,000-unit dose.

A clinical investigation of the value of these oral preparations in the treatment of pneumococcus pneumonia is in progress, and thus far 12 patients have been treated. The results are comparable to those observed following the intramuscular administration of penicillin. This study is being continued.

SUMMARY

It is possible to attain serum concentrations of penicillin after oral administration comparable to those attained after intramuscular injection by the use of approximately five times as much penicillin. As the concentrations attained following the ingestion of penicillin by four different methods were all of the same order of magnitude, it would seem that the present problem in oral administration is analogous to that with intramuscular administration, *i.e.*, to find the ideal vehicle whereby the duration of the serum concentration can be prolonged.

WALSH MCDERMOTT
PAUL A. BUNN
MARIA BENOIT
REBECKAH DUBOIS
WILLETTA HAYNES

DEPARTMENT OF MEDICINE,
CORNELL UNIVERSITY MEDICAL COLLEGE
AND THE NEW YORK HOSPITAL,
NEW YORK CITY

THE ROLE OF FECAL THIAMINE AND COCARBOXYLASE IN HUMAN NUTRITION[1,2]

THE role of the intestinal biosynthesis of thiamine in the nutrition of man and animal has recently been studied by several investigators.[3,4] Considerable amounts of thiamine have been found in human[5,6] and animal feces, but the question of whether this thiamine is readily available for body needs requires clarification.

We believe that the evidence cited in Tables 1 and 2 supports the concept that the thiamine and cocarboxylase in human feces is of no nutritional value to the individual, since it appears to exist largely within

[1] From the Medical Research Laboratories, Beth Israel Hospital, and the Department of Medicine, Harvard Medical School, Boston.

[2] This investigation has been aided by a grant from the Josiah Macy Jr. Foundation.

[3] V. A. Najjar and E. Holt, *Jour. Am. Med. Asn.*, 123: 683, 1943.

[4] C. A. Elvehjem, *Am. Sci.*, December, 1943.

[5] K. Ritsert, *Klin. Wchnschr.*, 17: 1397, 1938.

[6] B. Alexander, *Jour. Biol. Chem.*, 151: 455, 1943.

[7] P. C. Leong, *Biochem. Jour.*, 31: 373, 1937.

the bodies of bacteria and other organisms in the feces. The evidence further indicates that neither thiamine nor cocarboxylase are absorbed when physiological amounts are administered in a retention enema.

TABLE 1

FECAL THIAMINE AND COCARBOXYLASE

Stool weight gm	Thiamine content		Cocarboxylase* content	
	Per gm stool mcg	Total mcg	Per gm stool mcg	Total mcg
100	0.81	81	5.63	563
231	0.87	200	4.37	1,010
125	0.97	121	5.22	840
74	0.81	60	11.70	870
295	0.75	220	4.10	1,210
174	0.63	110	5.00	870
83	0.28	23	6.10	504
108	1.12	121	5.18	559
108†	0.53	57	...	...

* Expressed in terms of thiamine.
† An aliquot of the preceding stool; this aliquot was suspended in water and passed through a Seitz filter before analysis.

The analytical values for thiamine and cocarboxylase, obtained by chemical analysis,[6] in the human feces from a normal subject whose daily dietary intake consisted of 2,400 calories show that the feces contain more of these substances than any tissue of the body. The concentration of each substance is remarkably constant, and the ratio of free to phosphorylated thiamine is of the same order as that of tissues. Removal of organisms from a water suspension of feces by Seitz filtration results in a marked decrease in the thiamine present. This indicates that the thiamine exists largely in the bodies of fecal organisms.

TABLE 2

THE EFFECT OF A RETENTON ENEMA CONTAINING THIAMINE AND COCARBOXYLASE ON THEIR EXCRETION IN URINE AND FECES

	Fecal thiamine and cocarboxylase						
	24-hour urinary thiamine mcg	24-hour free thiamine mcg	Expected* free thiamine mcg	Recovery of expected free thiamine per cent.	Cocarboxylase† mcg	Expected* cocarboxylase mcg	Recovery of expected cocarboxylase per cent.
Before enema	116	121	...	...	559	...	...
	108	...	...	...	...	...	...
After enema	107	490	418	117	3,050	2,690	118

* Calculated on basis of stool weight times average concentration of thiamine and cocarboxylase in stools of same subject (Table 1); to this is added the amount of thiamine (0.25 mgm) and cocarboxylase (2.0 mgm) in the retention enema.
† Expressed in terms of thiamine.

Najjar and Holt[3] administered 50 mgm of thiamine rectally to two subjects on successive days. They observed rises in urinary thiamine excretion and from that concluded that the large intestine could absorb thiamine. It must be pointed out, however, that 50 mgm of thiamine is a huge dose compared with the amounts of thiamine normally present in human feces. Furthermore, most of the thiamine in feces is in the form of cocarboxylase, whereas they administered only thiamine. Cocarboxylase can not be absorbed as such and must first be split by dephosphorylating enzymes. It is dubious whether such enzymes exist in the large intestine.

Our experiment was devised to be more physiological. A retention enema, containing twice the amount of free and phosphorylated thiamine in the average 24-hour stool, was administered and retained for 24 hours. Not only was there no increase in the urinary thiamine excretion, but all the administered thiamine and cocarboxylase were recovered as such from the next 24-hour stool.

BENJAMIN ALEXANDER
GRETA LANDWEHR

DEAMINATION OF AMINO ACIDS BY THE HUMAN ORAL FLORA; ITS ROLE IN DENTAL CARIES IMMUNITY*

IT has been demonstrated in numerous studies that certain aciduric bacteria, particularly *L. acidophilus*, are missing from the mouths of patients who have no active caries.[1, 2, 3] It has also been shown that the saliva of these individuals does not rapidly convert glucose into acid.[4, 5] Viable *L. acidophilus* inoculated into the saliva or oral cavities of such individuals have disappeared from cultures made six to eight hours later.[6] The cause for the elimination of these bacteria and the inhibition of fermentation has been sought.

We found that human saliva inoculated into beef broth medium incubated for eight days and then filtered through a Seitz filter contained something that was bactericidal to *L. acidophilus*. When a small quantity of this filtrate was added to a saliva which would by itself degrade glucose rapidly, no acid was formed.

Experiments proved this inhibiting factor to be ammonia nitrogen. When a solution of an ammonium salt having a pH of 6.8 or above was added to saliva in the same concentrations of ammonia nitrogen as produced in salivary cultures, similar effects were obtained. Amounts as low as 0.5 mgm of ammonia nitrogen per ml were found efficient in inhibiting *L. acidophilus* growth and in preventing fermentation of

* Study assisted by a grant from John W. Ruettinger.

1 Herman Becks, Arthur L. Jensen and Compton B. Millar, *Jour. Am. Dental Asn.*, 31: 1189, 1944.
2 P. Jay, M. Crowley, F. Hadley and R. W. Bunting, *Jour. Am. Dental Asn.*, 23: 846, 1936.
3 R. G. Kesel, *Jour. Am. Dental Asn.*, 30: 25, 1943.
4 E. C. Wach *et al.*, *Jour. Dent. Res.*, 22: 415, 1943.
5 L. S. Fosdick, H. L. Hansen and Genevieve Epple, *Jour. Am. Dental Asn.*, 24: 1275, 1937.
6 T. J. Hill, *Jour. Am. Dental Asn.*, 26: 239, 1939.

glucose. Solutions of sodium and potassium salts having the same pH were non-inhibiting.

Grove and Grove[7, 8] called attention to the importance of ammonia in saliva several years ago, but the significance of their observations has not been grasped, perhaps because large quantities of ammonia nitrogen were not detected in the saliva of caries immunes. Small concentrations of ammonia formed more or less continuously on the vulnerable surfaces of the teeth may confer a natural protection against dental caries. The above authors as well as Stephan[9] have reported lowering caries incidence in many cases by using ammonia and urea mouth rinses.

The question arises as to what is present in the salivas of caries-free individuals that provides the ammonia. Early studies by us indicate that the source is not alone urea or mucin but the presence of various amino acids. Twenty-three amino acids alone and in various combinations have been checked for the possibility of ammonia production from them by the enzyme systems of the bacteria previously found in the salivary cultures.

Preliminary experiments have revealed that caries-immune individuals have enzyme systems capable of converting at least six amino acids into ammonia nitrogen. The six are arginin, alanine, aspartic acid, asparagin, glutamic acid, isoleucine and serine. Certain combinations of these amino acids proved much more effective. A wide variance of enzyme systems have been found in salivas from persons whose teeth are actively decaying. However, there seems to be in most instances an absence in the saliva of caries-active patients of a system that will convert glutamic acid to ammonia.

Microbiologic assays are now underway to determine the amino acid content of caries-immune and caries-active salivas. Our study to date suggests that caries immunity is based on the production of minute but continuous amounts of ammonia in the bacterial plaque resident on the tooth surface. The pabulum from which the ammonia is derived is apparently a small group of amino acids. These are present in the mouth as a result of the type of diet and body metabolism.

ROBERT G. KESEL
JOSEPH F. O'DONNELL
ERNST R. KIRCH

COLLEGE OF DENTISTRY AND
COLLEGE OF PHARMACY,
UNIVERSITY OF ILLINOIS,
CHICAGO, ILLINOIS

[7] C. T. Grove and C. J. Grove, *D. Cosmos*, 76: 1026, October, 1934.

[8] C. T. Grove and C. J. Grove, *Jour. Am. Dental Asn.*, 29: 1215, 1942.

[9] R. M. Stephan and B. F. Miller, *Proc. Soc. Exp. Biol. and Med.*, 55: 101, 1944.

THE PREPARATION OF HIGHLY PURIFIED PR8 INFLUENZA VIRUS FROM INFECTED MOUSE LUNGS[1]

ONE of the most convincing lines of evidence in establishing that tobacco mosaic virus activity is a specific property of a characteristic high molecular weight nucleoprotein was the demonstration that preparations of the virus protein from different species of plants, some of which were widely removed from the tobacco family, possessed essentially the same chemical, physical and biological properties.[2] This approach has not heretofore been used for viruses affecting animals because essentially pure preparations of virus from different animal hosts have not been available. Recently, highly purified preparations of PR8 influenza virus have been obtained from the allantoic fluid of infected chick embryos.[3, 4] These preparations contain particles about 100 mμ in diameter possessing characteristic chemical, physical and biological properties.[3-9] It appeared, therefore, that if one could isolate a comparable product from another host, an approach similar to that used for tobacco mosaic virus could be made and thus provide important data on the nature of influenza virus produced in different hosts. The possibilities of comparison were enhanced by the fact that influenza virus appears to possess at least two major forms of biological activity, namely, virus activity and red cell agglutinating capacity.

An attempt was made therefore to obtain purified preparations of PR8 influenza virus from suspensions of infected mouse lungs. When methods of centrifugation alone were employed, such as had been used previously by other workers,[10, 11] it was discovered that preparations were obtained which had low chick-cell agglutinating (CCA) activities and which obvi-

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and The Rockefeller Institute for Medical Research.

[2] W. M. Stanley, *Physiol. Rev.*, 19: 524, 1939.

[3] A. R. Taylor, D. G. Sharp, D. Beard, J. W. Beard, J. H. Dingle and A. E. Feller, *Jour. Immunol.*, 47: 261, 1943.

[4] W. M. Stanley, *Jour. Exp. Med.*, 79: 255, 1944.

[5] A. R. Taylor, *Jour. Biol. Chem.*, 153: 675, 1944.

[6] C. A. Knight, *Jour. Exp. Med.*, 80: 83, 1944.

[7] M. A. Lauffer and G. L. Miller, *Jour. Exp. Med.*, 80: 521, 1944.

[8] M. A. Lauffer and W. M. Stanley, *Jour. Exp. Med.*, 80: 531, 1944.

[9] G. L. Miller, M. A. Lauffer and W. M. Stanley, *Jour. Exp. Med.*, 80: 549, 1944.

[10] L. Hoyle and R. W. Fairbrother, *Jour. Hygiene*, 37: 512, 1937.

[11] L. A. Chambers and W. Henle, *Jour. Exp. Med.*, 77: 251, 1943.

ously contained large amounts of non-viral lung material. The procedure which was finally adopted and which led to a highly active product was one which combined the methods of adsorption on and elution from chicken red cells[12,13] and differential centrifugation. Four week-old mice from the colony of the Department of Animal and Plant Pathology of the institute were inoculated in a special chamber with an extremely fine spray of a 1 per cent. suspension of infected mouse lung[14] in 0.1 M phosphate buffer at pH 7. After about 72 hours, the mice were placed under deep ether anesthesia and their lungs were perfused with 0.85 per cent. saline and removed. The lungs were ground in 9 times their weight of 0.1 M phosphate buffer at pH 7 in a Waring Blendor, and the resulting suspension was angled in a low-speed centrifuge to remove gross particles. Such clarified 10 per cent. suspensions were accumulated and stored at about −70° over the course of 3 months until somewhat more than a liter had been obtained. The frozen material was then thawed, mixed thoroughly, and centrifuged to remove insoluble matter. The supernatant liquid possessed 113 standard CCA units[15] per ml and 50 per cent. infectivity endpoints in mice[16] and in chick embryos[17] at $10^{-6.6}$ ml and $10^{-8.7}$ ml, respectively. To 1,380 ml of cold clarified suspension were added 14 ml of chicken red cells. After standing overnight, the red cells were removed by centrifugation. The virus was then eluted from the red cells by incubation at 37° for 90 minutes in 200 ml of 0.1 M phosphate buffer at pH 7 and the resulting product was freed from blood elements by 2 cycles of differential centrifugation. This process yielded a product possessing more than 130 times the CCA activity of the starting material on a mg of nitrogen basis, but the value, 11,200, was still low compared to the CCA activity of chick embryo virus. Hence the adsorption and elution process was repeated followed by 2 additional cycles of differential centrifugation. The final product possessed about 28,000 CCA units per mg of nitrogen, a value which compares favorably with that of PR8 virus preparations obtained from allantoic fluid and which is about 17 times that of the best preparations obtained from mouse lungs by centrifugation alone. In so far as determined, the physical, chemical and biological properties of the purified material obtained from infected mouse lungs are indistinguishable from those of purified preparations of PR8 virus obtained from allantoic fluid. The preparation was highly infectious for both mice and embryos and gave 50 per cent. infectivity endpoints at 10^{-11} and 10^{-13} grams of nitrogen in mice and in chick embryos, respectively. In contrast to the bulk of material in preparations obtained from mouse lungs by centrifugation alone, the product obtained by the combined methods was soluble in 0.1 M phosphate buffer at pH 7 and gave a good boundary in the analytical ultracentrifuge. The sedimentation constant corrected for the viscosity of the preparation was 683S.[8] Electron micrographs revealed approximately spherical particles which were indistinguishable from those of the virus produced in chick embryos. The material was isoelectric at pH 5.4, contained about 10 per cent. of nitrogen and 7 per cent. of carbohydrate and precipitated strongly with antiserum to PR8 virus grown in chick embryos. As will be described in greater detail elsewhere, it is believed that a preparation of PR8 influenza virus has been obtained from infected mouse lungs that possesses essentially the same physical, chemical and biological properties as the virus preparations obtained from the allantoic fluid of chick embryos infected with PR8 influenza virus. The facts that the 2 hosts from which highly active preparations of virus have now been obtained are of such decidedly different nature and the sites of infection are so dissimilar, add to the significance which the findings have regarding the nature of viruses which infect animals and the use of heterologous sources of virus in the production of prophylactic vaccines.

C. A. KNIGHT

THE ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH,
PRINCETON, N. J.

[12] G. K. Hirst, SCIENCE, 94: 22, 1941.
[13] L. McClelland and R. Hare, *Can. Pub. Health Jour.*, 32: 530, 1941.
[14] The mouse-adapted strain of PR8 influenza virus used was kindly provided by Dr. G. K. Hirst.
[15] G. L. Miller and W. M. Stanley, *Jour. Exp. Med.*, 79: 185, 1944.
[16] M. A. Lauffer and G. L. Miller, *Jour. Exp. Med.*, 79: 197, 1944.
[17] C. A. Knight, *Jour. Exp. Med.*, 79: 487, 1944.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

STERILITY TEST FOR PENICILLIN EMPLOYING CYSTEINE FOR INACTIVATION

CAVALLITO and Bailey[1] recently noted that cysteine was capable of readily inactivating a number of antibiotics including penicillin. This fact might be used to advantage in testing for the sterility of penicillin preparations.

For a preliminary test of the method, a penicillin solution containing 1,830 International Units and 10

[1] C. J. Cavallito and J. H. Bailey, SCIENCE, 100: 390, 1944.

mg of $NaHCO_3$ per ml and a cysteine solution containing 2 per cent. cysteine hydrochloride and 2 per cent. $NaHCO_3$ were prepared. Each solution was sterilized by Seitz filtration. To 6 ml of the sterile penicillin solution was added 3 ml of the sterile cysteine solution. This resulted in a penicillin to cysteine hydrochloride ratio of 183 I.U. to 1 mg. This mixture was incubated for 1 hour at 37° C aseptically, after which time a cylinder plate assay against *Staphylococcus aureus* showed no activity.

The incubated solution was immediately tested for its ability to inhibit the growth of *Staphylococcus aureus* A.T.C.C. No. 6538, *Bacillus subtilis* N.R.R.L. No. 558, and the anaerobe, *Clostridium botulinum* Type A, A.T.C.C. No. 7948, in Brewer's fluid thioglycollate medium.[2] Also studied was the possibility of including cysteine in Brewer's medium so that the penicillin solution need merely be added to the sterility test medium for both inactivation and the sterility test. The experimental data are presented in Table 1.

TABLE 1

GROWTH RESPONSE OF SEVERAL ORGANISMS TO PENICILLIN AND CYSTEINE SOLUTIONS ADDED TO BREWER'S THIOGLYCOLLATE MEDIUM*

Organism	Penicillin solution,	Cysteine solution,	Penicillin-cysteine solution,	Day showing growth			
				1	2	3	7
	ml	ml	ml				
None	1	0	0	–	–	–	–
"	0	1	0	–	–	–	–
Staph. aureus	1	0	0	–	–	–	–
" "	0	0	1	+	+	+	+
" "	1	1	0	+	+	+	+
B. subtilis	1	0	0	–	–	–	–
" "	0	0	1	+	+	+	+
" "	1	1	0	+	+	+	+
Cl. botulinum	1	0	0	–	–	–	–
" "	0	0	1	+	+	+	+
" "	1	1	0	+	+	+	+

* Test medium consisted of 15 ml of Brewer's thioglycollate medium in 18 × 250 mm tubes.

Further studies were made in which both Brewer's fluid thioglycollate medium (Table 2) and this medium containing an added 0.2 per cent. cysteine hydrochloride (Table 3) were employed. These solutions were sterilized by autoclaving. The penicillin sodium solution for these studies contained 8,350 I.U. per ml. The cysteine solution was prepared from a 2 per cent. cysteine hydrochloride solution neutralized to pH 7 with $NaHCO_3$. These solutions were sterilized by Seitz filtration. The penicillin-cysteine solution was prepared by mixing 6 ml of the penicillin solution with 3 ml of the cysteine solution aseptically. This mixture was incubated at 37° C for 1 hour before use. The penicillin to cysteine hydrochloride ratio was about 835 I.U. to 1 mg. Bacteriological test data are

[2] Difco Laboratories, Inc., Detroit, Michigan.

TABLE 2

GROWTH RESPONSE OF SEVERAL ORGANISMS TO PENICILLIN AND CYSTEINE SOLUTIONS ADDED TO BREWER'S THIOGLYCOLLATE MEDIUM*

Organism	Penicillin solution,	Cysteine solution,	Penicillin-cysteine solution,	Penicillin : Cysteine ratio	Day showing growth			
					1	4	6	7
	ml	ml	ml	I.U. : mg				
None	0	0	0	....	–	–	–	–
"	1	0	0	....	–	–	–	–
"	0	1	0	....	–	–	–	–
Staph. aureus	1	0	0	....	–	–	–	–
" "	0	0	1.2	835 : 1	–	+	+	+
" "	1	1	0	418 : 1	+	+	+	+
B. subtilis	1	0	0	....	–	–	–	–
" "	0	0	1.2	835 : 1	–	–	–	–
" "	1	1	0	418 : 1	–	+	+	+
Cl. botulinum	1	0	0	....	–	–	–	–
" "	0	0	1.2	835 : 1	–	+	+	+
" "	1	1	0	418 : 1	+	+	+	+

* Test medium as for Table 1.

modified Brewer's medium containing cysteine was employed.

With the ratio of penicillin to cysteine hydrochloride at 835 I.U. to 1 mg, the organisms which grew

TABLE 3

INACTIVATION OF PENICILLIN AND SUPPORT OF BACTERIAL GROWTH BY CYSTEINE CONTAINING STERILITY TEST MEDIUM*

Test organism	Penicillin solution,	Penicillin : cysteine ratio,	Day showing growth			
			1	4	6	7
	ml	I.U. : mg				
None	0	....	–	–	–	–
Staph. aureus	1	278 : 1	–	+	+	+
B. subtilis	1	278 : 1	–	+	+	+
Cl. botulinum	1	278 : 1	+	+	+	+

* Test medium consisted of 15 ml of Brewer's fluid thioglycollate medium containing 0.2 per cent. cysteine hydrochloride in 18 × 250 mm tubes.

given in Table 2, where Brewer's thioglycollate medium was employed, and in Table 3, where the were delayed in starting and *Bacillus subtilis* showed no activity in 7 days at the incubation temperature of 37° C. At the ratios of 418 and 278 I.U. of penicillin to 1 mg of cysteine hydrochloride all three test organisms proliferated well. In Table 3 it is evident that the modified Brewer's medium containing cysteine satisfactorily inactivated the added penicillin and supported the growth of all three test organisms.

Brewer's fluid thioglycollate medium employed in these studies was made from a commercial dehydrated powdered product.[2] Although thioglycollate was present in this medium, it is quite possible that the inclusion of cysteine would allow the elimination of the thioglycollate from the medium.

It is evident that should this method prove to be satisfactory for the sterility test, its simplicity would

be quite advantageous over the current sterility test methods.

RICHARD J. HICKEY

RESEARCH LABORATORIES,
COMMERCIAL SOLVENTS CORPORATION,
TERRE HAUTE, IND.

A METHOD FOR THE CULTURING OF EXCISED, IMMATURE CORN EMBRYOS IN VITRO[1]

THE culturing of excised, immature plant embryos *in vitro* is a very useful technique for the propagation of otherwise abortive embryos often encountered in hybridization work.[2, 3, 4] A method, adapted from that developed by van Overbeek *et al.*[4, 5] for *Datura*, was found applicable to the culturing of excised corn embryos[6] 8 to 10 days after pollination and 0.3 to 3 mm in length.

The ear of corn was carefully husked, dipped into 70 per cent. ethanol and washed with sterile distilled water. Then the corn kernels were cut from the cob aseptically into a sterile Petri dish. About 6 kernels were held between 2 microscope slides, which had been previously dipped in 70 per cent. ethanol and flamed, and cut with a sterile, thin razor blade. The embryos were lifted from the endosperm by means of sterile, spear-shaped dissecting needles and placed on the surface of the sterile culture medium contained in half-dram shell vials, fitted with cotton plugs. More rapid growth was obtained when the embryos were placed on the surface of the agar medium than when submerged. The vials were then incubated at 30° C.

Unlike *Datura*, 10-day-old proembryos over 0.3 mm in length did not require the addition of coconut milk to the medium described by van Overbeek *et al.*[4] for continued growth. For embryos smaller between 0.3 and 1 mm in length, however, a higher sucrose concentration of 5 per cent. must be used. Otherwise, no growth will result. Excised 10-day-old embryos below 0.25 mm in length did not grow even in the presence of coconut milk. Also, the growth of the embryos, particularly the epicotyl, was accelerated by the addition of 1.5 gm of asparagine per liter of culture medium. Thus, 10-day-old embryos with an initial length of 2 mm grew in the van Overbeek basic medium to a length of 13 mm in 10 days. With the addition of asparagine, comparable embryos in a parallel test grew to 27 mm in the same length of time.

[1] Work supported in part by Grant No. 720 of the American Philosophical Society, to which the authors are indebted.

[2] F. Laibach, *Jour. Hered.*, 20: 200, 1929.

[3] H. B. Tukey, *Proc. Am. Soc. Hort. Sci.*, 32: 313, 1934.

[4] J. van Overbeek, M. E. Conklin and A. F. Blakeslee, *Am. Jour. Bot.*, 29: 472, 1942.

[5] J. van Overbeek, R. Siu and A. J. Haagen-Smit, *Am. Jour. Bot*, 31: 219, 1944.

[6] We are indebted to Drs. J. L. Randolph and R. A. Brink for the suggestion of using corn embryos made at the recent Smith College embryo culture conference.

To give an idea of the rate of growth of corn embryos cultured *in vitro* at 30° C in van Overbeek's basic medium containing 5 per cent. sucrose, plus 1.5 mg asparagine and 0.001 gamma biotin per cc of culture medium, the average growth of 10-day-old corn embryos of different initial lengths is plotted in Fig. 1. Each initial size, with the exception of the largest, is represented by 30 to 60 embryos. The largest group represents the average of eight.

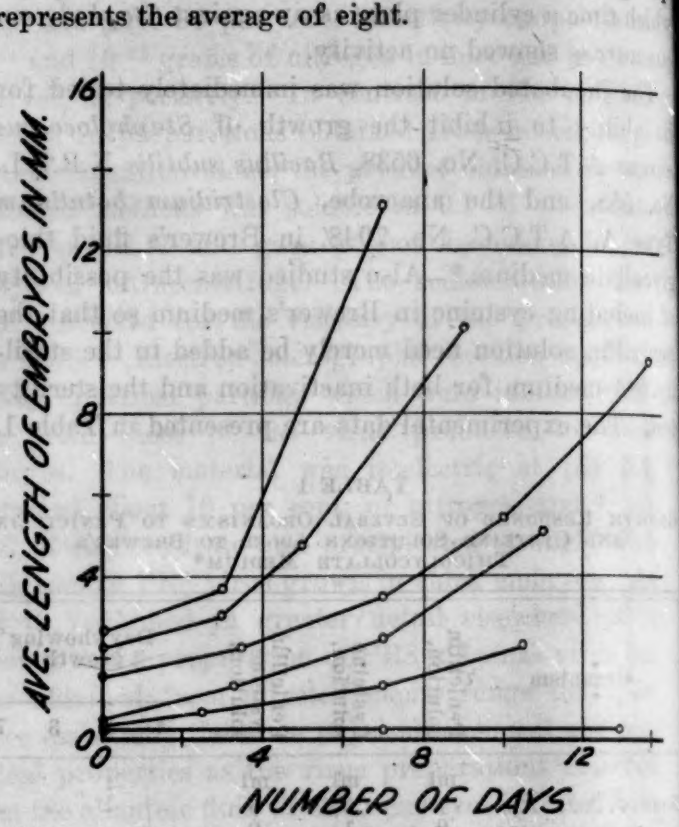

FIG. 1. Growth of excised 10-day-old corn embryos *in vitro*.

From the growth data presented above, it is apparent that the so-called "embryo factors" of coconut milk[4, 5] are not limiting for the survival of the corn embryo. Excised 10-day-old corn embryos above 0.3 mm in length do not require coconut milk for continued growth *in vitro*, while smaller embryos do not survive even with the addition of coconut milk to the medium. It seems likely, therefore, that the growth factors derived from the corn kernel, which are necessary for the growth of the corn embryo, are different from those in coconut milk, which are required by *Datura* proembryos.

A. J. HAAGEN-SMIT
R. SIU
GERTRUDE WILSON

CALIFORNIA INSTITUTE OF TECHNOLOGY

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